AERONAUTICAL ENGINEERING REVIEW

SEPTEMBER 1948

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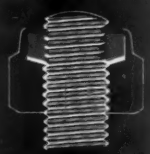

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CLINCH

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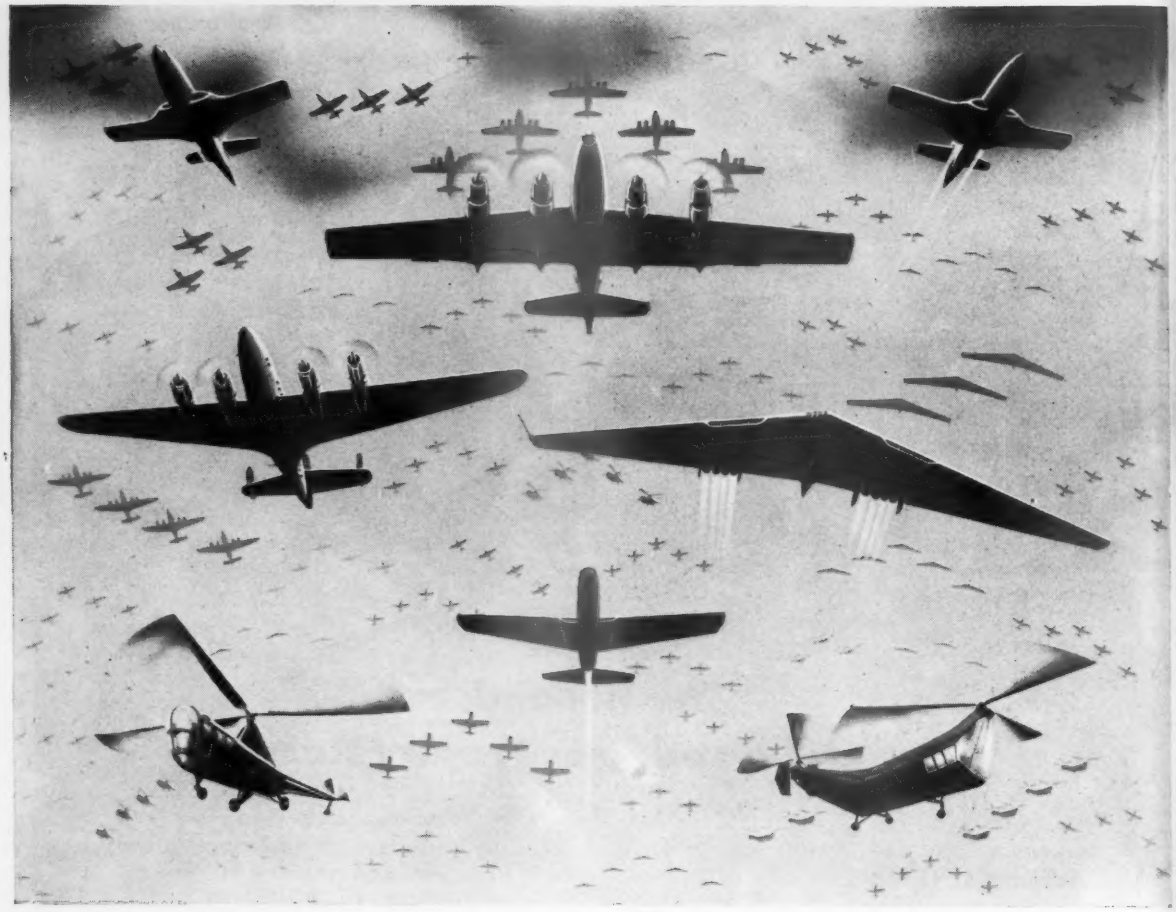

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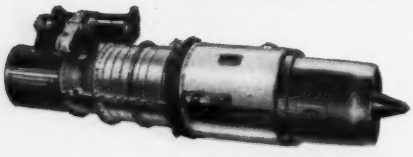
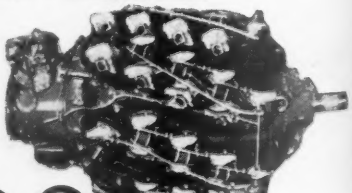


Accessory Drive on Turbo Jet Engine

Precision Gears on Pratt and Whitney Wasp Major



FOOTE BROS.

Better Power Transmission Through Better Gears

Official U.S. Navy Photograph

Cover—The KAN-2 (Little Joe) developed at Naval Test Center, Point Mugu.

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AERONAUTICAL ENGINEERING REVIEW

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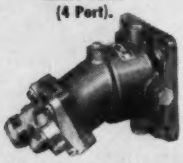

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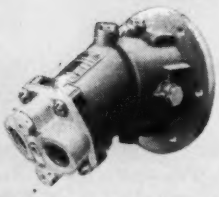

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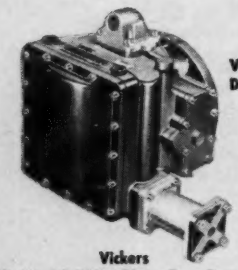

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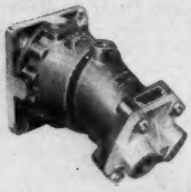

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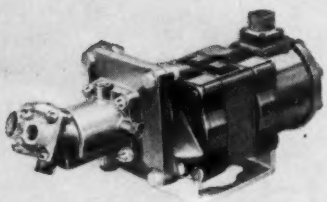

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

I.A.S. News

A Record of People and Events of Interest to Institute Members

Symington Praises Aircraft Industry at Dinner

Air Secretary Calls for Air Power Balance with Power of Potential Enemy, Instead of with Army or Navy; Northrop Presents Chanute, Bane Awards; Hayward Speaks

AIR FORCE SECRETARY W. STUART SYMINGTON, guest of honor and principal speaker at the Institute's Annual Summer Meeting Dinner at the Hotel Ambassador in Los Angeles, July 16, spoke in praise of the American aircraft industry for four noteworthy accomplishments.

▶ **Cites Accomplishments**—Mr. Symington congratulated the assembled aeronautical scientists and technicians for:

- Surpassing the speed of sound.
- New refueling technique which adds great range to bomber aircraft.
- Development of track-type landing gear.
- Performance of Convair B-36 which, he said, operates better at maximum range than any other bombing aircraft now in production.

Main theme of his "gloves-off" talk before the Institute members was the interdepartmental controversy between the three services and the "duplications and triplications" in service operations which he said must be stopped because they threaten to bankrupt the nation.

▶ **Deplores Service "Balance" Idea**—Assailing those "dedicated to obsolete methods" of warfare who contend that large air appropriations might "unbalance" the three services, Symington asserted air power should be put in balance not with Army or Navy but with the power of potential enemies.

The real way to economize, he said, was not by paring appropriations but by "true integration of the services." "Air power is still the No. 1 priority in the United States," Symington said, adding that "You cannot win a war without superiority, and you cannot lose one with it."

▶ **Bane, Chanute Awards**—At the dinner, John K. Northrop, I.A.S. President, presented the Institute's 1948 Octave Chanute and Thurman H. Bane awards to N.A.C.A. test pilot Herbert H. Hoover and Col. James M. Gillespie, U.S.A.F. (ret.), respectively, for outstanding contributions to aeronautical sciences during the year. (See page 6 for story.)

At the Luncheon gathering on the same day, Navy Comdr. J. T. Hayward, Director of Plans and Operations, Armed Forces Special Weapons Project, warned against becoming "obsessed with the idea that the atomic bomb is our 'Sunday punch.'"

Commander Hayward spoke also of the nuclear energy propulsion of aircraft and submarines, mentioning the immense problems encountered. (Excerpts of speech on page 32.)

The Dinner culminated the two-day Summer Meeting at which more than a dozen technical papers were presented by engineers and scientists of the Government and the aircraft industry, in addition to a Pilots' Symposium on special flight operational problems.

LOS ANGELES- 6 Aug. John K.Northrop President Institute of the Aero Sciences announced that contract had been signed for erection of L.A. facility building with estimated completion 15 May 1949.

SAN DIEGO- 16 Aug.- IAS President J.K. Northrop announced award of contract for erection S.D. facility building for estimated completion May 1949.

Northrop Presents Chanute, Bane Awards to N.A.C.A. Test Pilot, Former Air Force Colonel

TO THE TWO MEN who helped bring supersonic and push-button flight into the realm of reality, President John K. Northrop presented the Octave Chanute and the Thurman H. Bane awards in a ceremony at the Annual Summer Meeting Dinner of the Institute in Los Angeles at the Hotel Ambassador, July 16.

▶ **Flew at Supersonic Speed**—Herbert H. Hoover, Head of N.A.C.A.'s Langley Flight Research Operations, and one of four men who have flown in excess of the speed of sound, was the recipient of The Octave Chanute Award.

Former Air Force Colonel James M. Gillespie received The Thurman H. Bane Award. He commanded the automatic flight across the Atlantic to a Royal Air Force field in England last September. The C-54 that made the flight did so without human manipulation of the controls at any time. Colonel Gillespie himself did not know the predetermined destination until the push-button C-54 landed itself at Brize-Norton airfield.

Test Pilot Hoover has had a notable share in developing flight methods and personnel for scientific investigation in the transonic experimental Bell X-1 and the Douglas D-558 Skystreak research aircraft. An N.A.C.A. pilot for 7 years, Hoover has made some 2,500 flights, totaling close to 2,000 hours in many different types of planes.

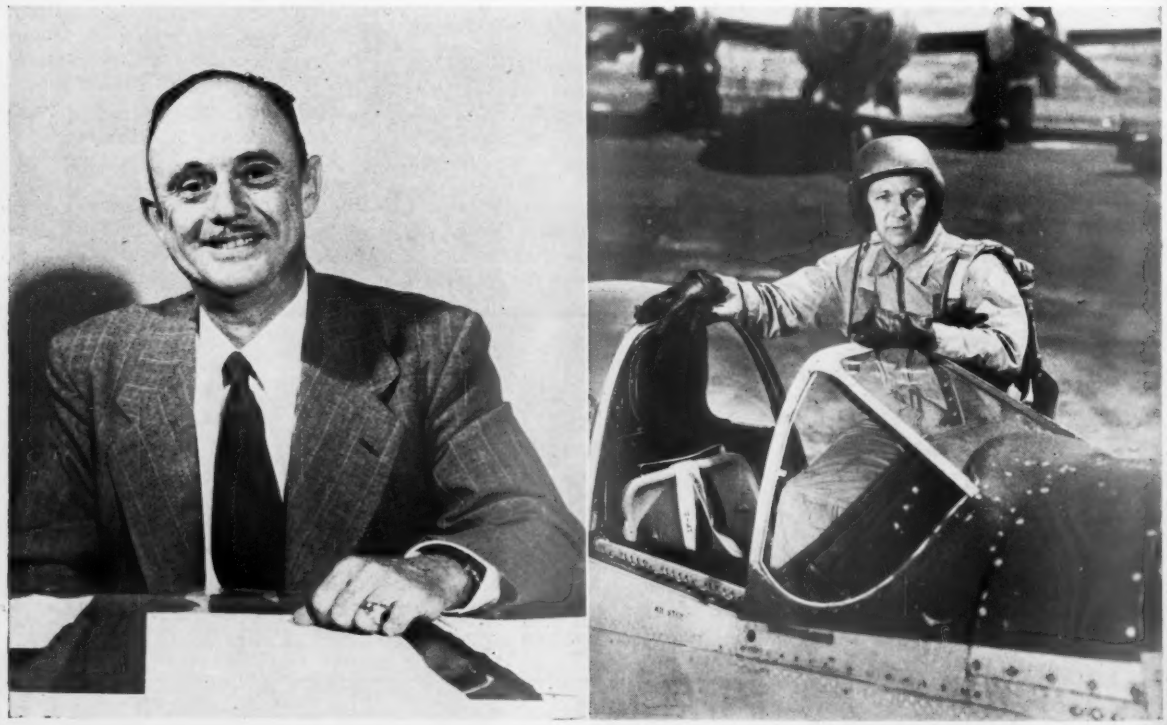
▶ **Awards Presented Annually**—The Octave Chanute Award is presented annually to a pilot for a notable contribution to the aeronautical sciences. It was established by the Institute in 1939 in memory of Octave Chanute, early experimenter with gliders, whose book *Progress in Flying Machines* published in 1884 and other research data and personal help encouraged the Wright brothers in their work on powered aircraft.

The Thurman H. Bane Award honors the memory of the late Col. Thurman H. Bane, former commanding officer of McCook Field, Dayton, Ohio, first headquarters of the Army's aeronautical research and development work now carried on by Air Materiel Command of the U.S. Air Force at Wright-Patterson Field. The Bane Award is presented annually to an officer or civilian of the Air Materiel Command for outstanding achievement in aeronautical development during the year.

Until his retirement from the Air Force on June 15, Colonel Gillespie commanded the All Weather Flying Division of the Air Materiel Command at Wilmington, Ohio. He has since accepted a position as technical Advisor with the Garrett Corporation. Colonel Gillespie was cited for preparing and executing the first long-range automatic push-button flights.

The Dinner at which President Northrop presented the awards culminated the 2-day Annual Summer Meeting of the Institute.

Winners of I.A.S. Bane and Chanute Awards: *Colonel James M. Gillespie (left), U.S.A.F. (ret.), who won the 1948 Thurman H. Bane Award for preparing and executing the first long-range automatic push-button flights, and Herbert H. Hoover (right), N.A.C.A. test pilot, recipient of the 1948 Octave Chanute Award for his part in preparing the scientific investigation of supersonic flights.*



Necrology

Dr. George William Lewis

Dr. George William Lewis, Research Consultant to the National Advisory Committee for Aeronautics and former Director of Aeronautical Research for the N.A.C.A., died on July 12 at his summer home at Lake Winola, Pa., at the age of 66.

▸ **I.A.S. Past-President**—An Honorary Fellow and Past-President of the Institute of the Aeronautical Sciences, Dr. Lewis has directed the N.A.C.A. since November, 1919.

Designated as Executive Officer in 1919, he was named Director of Aeronautical Research in 1924, resigning from that position in August, 1947. He was retained by N.A.C.A. as Research Consultant up until the time of his death.

During his period of leadership, the N.A.C.A. has grown from a staff of 43 employees to an organization of more than 6,000, including many recognized leaders in specialized branches of aeronautical science. Under its prescribed function to "supervise and direct the scientific study of the problems of flight," N.A.C.A. has been developed by Dr. Lewis from a small laboratory consisting of one wind tunnel worth $5,000 to the Committee's existing three major research centers, which have a plant value in excess of $90,000,000.

▸ **Pioneered Research Equipment**—With broad vision of the growing research needs of aviation and with high professional courage, Dr. Lewis pioneered in the design and construction of novel research equipment and is responsible for the introduction of new methods of flight research. In addition, he made original use of variable-density wind tunnels, refrigerated wind tunnels, full-scale wind tunnels, free-flight wind tunnels, gust tunnels, and high-speed tunnels.

Other pioneering projects were: design and construction of new facilities for propeller research, seaplane research, and structural and power-plant research.

Born in Ithaca, N.Y., in 1882, Dr. Lewis was educated at Cornell University, graduating with the degree of Mechanical Engineer in 1908. Remaining at the university as instructor in the Engineering College, he obtained his Masters Degree in Mechanical Engineering in 1910.

While at Cornell he collaborated with Prof. C. B. Upton in the development of the Upton-Lewis fatigue-testing machine.

In 1929 Dr. Lewis was honored by the American Society of Mechanical Engineers by being selected as one of the ten men most responsible at that time for advances made in aeronautical science in the United States. He also received the Honorary Degree of Doctor of Science from Norwich University.

▸ **Guggenheim Medalist**—The Guggenheim Medal, a high aeronautical honor, was awarded Dr. Lewis for outstanding success in the direction of aeronautical research and the development of original research equipment and methods.

In 1937 he was appointed by President Roosevelt as Plenipotentiary Delegate of the United States to the Inter-American Technical Aviation Conference in Lima, Peru, and in 1941 he was appointed a member of the U.S. National Commission of the Permanent American Aeronautical Commission.

▸ **Wilbur Wright Lecturer**—The Royal Aeronautical Society invited Dr. Lewis to deliver the 1939 Wilbur Wright Memorial Lecture in London.

Other honors received by Dr. Lewis were:

- Honorary Degree of Doctor of Engineering by University of Illinois, in 1944.
- Spirit of St. Louis Medal by A.S.M.E., 1944.
- Elected a Member of National Academy of Science, 1945.
- Awarded Medal for Merit in 1948 for exceptional contributions during the war.
- N.A.C.A. Testimonial for past services.

Fairchild Donation Starts Depew Memorial Fund

Sherman M. Fairchild, pioneer aviation developer, made the first financial donation to the Flight Safety Foundation, Inc., with which to start the Richard Henry Depew, Jr., Memorial Fund for greater safety in private flying.

There was a small ceremony in honor of the occasion at the Wings Club, Hotel Biltmore, New York City, at which Mrs. Depew, widow of the veteran flier who died suddenly last January 28, was present. Jerome Lederer, President of the Flight Safety Foundation, an independent, nonprofit organization, received the donation on behalf of the corporation.

▸ **To Aid Scientific Research**—The gift of Mr. Fairchild, according to Mr. Lederer, will make possible the creation of a fund to be used for scientific study, research, experimentation, and education in the fields of personal aircraft design, equipment, and practice which are "too often overlooked because of the more immediately press-

ing demands of commercial and military aviation."

It is understood that the donation is but the first of several for this purpose.

Littlewood Elected to Board of Cornell Aero. Lab.

William Littlewood, American Airlines' Vice-President in Charge of Engineering, was elected to the Board of Directors, the Cornell Aeronautical Laboratory, Inc., late in June. He becomes the 14th member of the board, which was organized in May under the new corporate status of the laboratory.

▶ **Cornell Graduate**—A graduate of Cornell, Class of 1920, Bill Littlewood entered aviation in 1927 with the Fairchild Engine Company. He helped to engineer and build the Caminez "Cam" engine, produced the Armstrong Siddeley "Genet" engine in the United States, fabricated the majority of Wright-de Havilland "Gypsy" production in this country, and built the first Ranger aircraft engines.

He joined the engineering department of American Airways, predecessor of American Airlines System, in 1930, was made Chief Engineer in 1933, and Vice-President in Charge of Engineering in 1937. He also was named Vice-President for Engineering for American Overseas Airplanes in 1945.

▶ **Awarded Wright Bros. Medal**—In 1935 Mr. Littlewood was awarded the Wright Brothers Medal for an "outstanding contribution to aviation," presented annually by the S.A.E.

Chairman of the Committee on Operating Problems of the National Advisory Committee for Aeronautics, he is a Fellow and Past Vice-President of the Institute of the Aeronautical Sciences.

I.A.S. Newslines

▶ Re-elected. . . **Dr. H. Roxbee Cox,** Director of National Gas Turbine Establishment, Great Britain, and Fellow of I.A.S., has been re-elected President of the Royal Aeronautical Society for 1948–1949.

▶ New N.A.C.A. Member. . . Wartime commander of Eighth Air Force, **Lt. Gen. James H. Doolittle** has been sworn in as a member of the National Advisory Committee for Aeronautics for term expiring December 1, 1950.

National Meetings Calendar

October 14–15	Military Aeronautics Meeting, Dayton, Ohio
December 17	Wright Brothers Lecture, Washington, D.C.
January 24–27	Seventeenth Annual Meeting, New York

For details see page 53.

I.A.S. Honorary Fellow Doolittle is a pioneer engineering test pilot who made first completely "blind landing."

▶ Executive Vice-President of Consolidated Vultee Aircraft for past 5 years, **I. M. Laddon,** a Fellow and Member of I.A.S. Advisory Committee, resigned July 9. He remains a member of Convair Board of Directors.

▶ Formerly Director of Research & Development, General Tire & Rubber Company of California, **Dr. Norton B. Moore,** Associate Fellow, has been named Chief Engineer, Guided Missiles Division, McDonnell Aircraft Corporation.

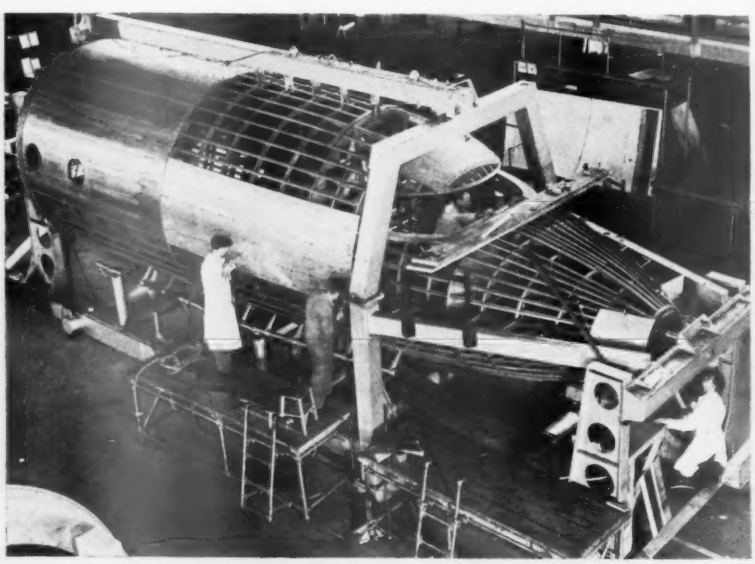
▶ Receives Honorary Degree. . . I.A.S. President **John K. Northrop** received the honorary degree of Doctor of Science from Occidental College in recognition of his work in aeronautical engineering fields.

▶ Eastern Rotorcraft Partner. . . **Julian P. Perry,** who was Chief Engineer of Helicopter Aircraft, Firestone Aircraft Company, has joined Eastern Rotorcraft Company as General Partner. He is an I.A.S. Associate Fellow.

▶ New assistant to the Chairman of the Board, Consolidated Vultee Aircraft Corporation, **William C. Rockefeller,** an Associate Fellow, resigned as General Manager of Alvin P. Adams & Associates to take the Convair post.

▶ Editor Spaatz. . . *Newsweek* magazine has announced that **Gen. Carl Spaatz,** retired Air Force Chief of Staff and wartime commanding general of the U.S. Strategic Air Force, has joined its staff as air and military consultant and contributing editor. Taking up his duties in his first civilian assignment the first of August, Editor Spaatz is writing a column on military and air matters under his own signature.

▶ Made Honorary Fellow. . . The Royal Aeronautical Society awarded an Honorary Fellowship to **Sir Alliott Verdon-Roe,** President and Director, Saunders-Roe Ltd. Sir Alliott, who is a Fellow of I.A.S., is also Chairman of Aviation Developments Ltd. The



PROGRESS IN CANADIAN JET TRANSPORT

Nose section of the C.102 jet transport under construction at the A. V. Roe Canada Limited plant, Malton, Ontario. The Canadian jet air liner is a short medium-range type of 36–40 passenger capacity, powered by four Rolls-Royce Derwent Mark 5 gas turbines with cruising speed of 400 m.p.h. Fuselage is divided into five main components: nose, center section, rear center section, rear section, and tail cone. Center part of main plane is integral with the fuselage center section and incorporates engine nacelles. Prototype is expected to fly in February, 1949.

R.Ae.S. Honorary Fellowship was awarded at conclusion of last Wilbur Wright Memorial Lecture on May 27.

▶ Self-sustaining. . . .**T. P. Wright,** Honorary Fellow and Past-President of the Institute (1938), announced that Cornell Aeronautical Laboratory, Inc., which was presented to Cornell University in 1946 by Curtiss-Wright Corporation, has liquidated its last financial obligation to Cornell and is on a completely self-sustaining basis. The Laboratory, of which Mr. Wright is President, was incorporated last Spring and is capitalized at approximately $4,500,000.

Corporate Member News

• Transatlantic Milestone. . .**American Overseas Airlines** entered its seventh year of transatlantic service in the last week of June. When first inaugurated to Europe in 1942, service was three departures per week; last June, A.O.A. operated 22 round trips in the final week. Passengers in the 6-year period totaled 134,580; and passenger-miles flown, 505,000,000. Cargo and mail volume exceeded 5,000,000 lbs.

• $300,000,000 Backlog. . .Entering its 33rd year in the plane manufacturing business in July, **Boeing Airplane Company** chalked up a $300,000,000 backlog of unfilled military and commercial orders. About $80,000,000 is in commercial contracts. Figures do not include initial orders under new 70-group Air Force program.

• Getting to the bottom of it. . .**Consolidated Vultee Corporation,** in an intensive research program to determine what type of seats best meet air-line needs from standpoint of passenger comfort, long life, and ease of maintenance, telescoped the wear and tear of a 5-year period into a week's project. Plaster mold in standardized human "buttock form," with lead weights added, was impressed 100,000 times against seat cushions under tests.

• Industrial manufacturer. . .Expansion of the **Douglas Aircraft Company, Inc.,** into the western market as a large-scale manufacturer of nonaircraft products has been announced with establishment of Metal Products Division for manufacture of wide variety of pressed metal products. Decision to set up new division was based solely on conviction that Pacific slope and industrially attached territory offer great opportunity for development and expansion in this field and was not influenced by fluctuations in aircraft manufacturing, Douglas said.

• Trippling Jet Engine Production. . .Leasing a wartime plant at Lockland, Ohio, **General Electric Company** will triple its capacity production of jet engines at the Lynn, Mass., plant. Known as the North plant, new factory has floor space of 700,000 sq.ft., will employ more than 2,000 at peak production, and will have facilities for assembly and test of the TG-190 (Air Force J-47) jet, which powers North American F-86. Component parts will be subcontracted to the aviation industry.

• Multimillion Dollar Research Center. . .Six buildings, completely equipped with scientific tools and equipment, have been opened by **The B. F. Goodrich Company** on a 261-acre site at Brecksville, Ohio, between Akron and Cleveland, as a new research center.

• Graduate engineers, draftsmen, designers wanted. . .**The Goodyear Aircraft Corporation,** subsidiary of The Goodyear Tire & Rubber Company, spread the welcome mat for graduate engineers, designers, and trained draftsmen early last July to "keep pace with the accelerated program in the aviation industry stimulated by Government appropriations to strengthen U.S. military power." Work now in progress, Goodyear said, is mostly in preliminary design stages, involving aircraft design and components, including wheels and brakes, air-frame construction, fuel tanks, free blown and rotiformed Plexiglas canopies, and other basic aeronautical structural, mechanical, and electronic developments.

• Piling up. . .Robert E. Gross, **Lockheed Aircraft Corporation** President, said that additional Air Force, Navy orders totaled approximately $92,000,000 in July—increased company's backlog to around $182,000,000.

• A guided missile engineering division has been set up by **McDonnell Aircraft Corp.**

• Aluminum casting added. . .**North American Aviation, Inc.,** has expanded its foundry facilities to include aluminum casting, permitting close control of specialized casting.

• New Northrop Company. . .Called The Turbodyne Corporation, a new firm has been set up by **Northrop Aircraft, Inc.,** which bought the interest of the Joshua Hendy Iron Works in the gas-turbine development of the Northrop-Hendy Company. Now owned wholly by Northrop, the company is being operated as an autonomous subsidiary, conducting its own development program independently. Operations are exclusively in gas turbines, and the firm is continuing work on the 10,000-hp "Turbodyne". . .Northrop has begun a ground-crew service training program under which some 80 enlisted men and civilian employees will participate. Training, involving service, maintenance, and repair of B-35 and B-49 Flying Wing bombers will require about 5 weeks.

• Tokyo Housing Project. . .Work has started on a housing project in Tokyo for **Northwest Airlines, Inc.,** employees and their families. Contract, first signed between American and Jap company since the war, provides for 20 separate dwellings including servants' quarters, garages, and all modern American facilities.

• Corrosion Preventive. . .**Pan American World Airways System** reports experiments in corrosion prevention to reduce losses in engine parts and delicate instruments caused by high humidity have resulted in development of a crystalline compound that gives off a gas when in contact with moist air. The gas inhibits rust, and the material can be spread on like moth flakes and has no harmful effects even inside engine. Containing no abrasive qualities, it dissipates without leaving sludge or carbon traces on engine running.

Silicone News

DC SILICONES

IN BLIZZARD OR HEAT-WAVE . . .

Fortunately for men and machinery, blizzards come in season. We have time to prepare for them with heavier clothes and thinner lubricants. But it is not practical to change lubricants in aircraft that take off in tropical heat and fly into sub-zero weather, or in the parking meters that line the main streets of cities and hamlets from the Yukon to the Rio Grande.

Photo Courtesy Mi-Co Meter Division, Michaels Art Bronze Co.

Dow Corning Silicone Oil, DC 550R lubricates 8 moving parts and enables Mi-Co parking meters to give trouble-free service the year around.

The problem in such cases is to find a lubricant which does not run out when hot, thicken when cold, or gum up with age. That's why many manufacturers like the Mi-Co Meter Division of the Michaels Art Bronze Co. Inc., of Covington, Kentucky, are using DC Silicone Oils or Greases.

Mi-Co Meter required a lubricant that would not thicken or thin out enough to alter the performance of parking meters exposed to temperatures ranging from −40° to 150° F. Field testing under the sun of California and in the blizzards of Fairbanks, Alaska proved that one of our silicone oils, DC 550R, was superior to any other lubricant tested. Now all Mi-Co Meters are factory lubricated with DC 550R.

Dow Corning Silicone Oils and Greases are used in a wide variety of applications from automatic toaster timers to 6 inch roller bearings exposed to temperatures up to 700° F. If your lubrication problems involve high or low temperatures, weathering, or a combination of all three, phone our nearest branch office or write for data sheet C5-95 on DC Silicone Oils or data sheet D1-S on DC Silicone Greases.

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FIRST IN SILICONES

Meet Your Section Chairman

William R. Enyart

New York Section

For the past 10 years, William R. Enyart has headed, as General Manager and President, the aeronautical engineering and equipment manufacturing firm of Simmonds Aerocessories, Inc.

Elected the 1947–1948 Chairman of the New York Section of the Institute of the Aeronautical Sciences, his chairmanship has been featured by pioneering activity in such symposium-type Section meetings as the Aircraft Propulsion Forum and in such Section membership field trips as the Inspection Tour of La Guardia Airport and the U.S.S. "Coral Sea" Aircraft Carrier Trip.

▶ **Fred Weick's Classmate**—Born in Connersville, Ind., in 1901, Enyart was graduated from the University of Illinois with a B.S. in Mechanical Engineering, specializing in aeronautics.

He and Fred Weick of Ercoupe fame, as mechanical engineering classmates at Illinois, were early aviation enthusiasts. At Illinois, Enyart was active in organization of the original Illinois R.O.T.C. Unit and the Illinois Flying Club.

Upon his graduate appointment in 1923 as a Lieutenant in the Air Corps Reserve, he was one of a small group selected from several of the then existing university Aviation R.O.T.C. units as a student officer for flight training with the West Point Class of 1923 at Army flight schools at San Antonio, Tex.

▶ **Transport Pilot**—In addition to his Air Corps wings won in 1923, Enyart was an early holder of a Department of Commerce Transport Pilot's rating and a Fédération Aéronautique Internationale Soaring Pilot's rating.

His long activity in association work dates back to his Presidency in Engineering School days of the student branch at Illinois of the American Society of Mechanical Engineers. He was one of the first secretaries of the Air Reserve Association and has served as an officer or director of many aviation organizations.

▶ **'Airway Age' Editor**—In the latter 20's and early 30's, Enyart was active in aviation as Technical Editor for *Airway Age*, one of the leading technical publications of that period. He also was an associate with J. S. McDonnell, Jr., in the development of the famous "Doodlebug" entrant in the Guggenheim Safe Aircraft Competition.

Other activities:

- President, National Aeronautic Association, 1937–1941.
- Director, Soaring Society of America, 1932–1941.
- Vice-President and member Comité Directeur, Fédération Aéronautique Internationale, 1946–.
- Vice-President, Private Fliers Association.
- Chairman, Alumni Association Advisory Committee for Aviation, University of Illinois, 1946–1947.
- Official Representative of world private air touring, International Civil Aviation Organization (ICAO).

Paul J. Burr

Philadelphia Section

Commander Paul J. Burr, U.S.N., active in aviation for 19 years as a Naval Aviator and aeronautical engineer, presently is Director of the Naval Air Experimental Station, Philadelphia, to which post he was given orders last May.

Accepted as a Member of the Institute in 1946, Commander Burr is the 1948–1949 Chairman of the Philadelphia Section. He was educated at Drexel Institute of Technology in Philadelphia, and in 1929 he was graduated from the Naval Flight Training Station at Pensacola, Fla., as a Naval Aviator. He was commissioned an Ensign in the Naval Reserve.

▶ **Held in High Regard**—Following a year of active duty with the U.S. Fleet aboard the U.S.S. "Trenton," Burr worked at Keystone Aircraft Corporation, Curtiss Airplane Corporation, and Bell Aircraft Corporation, where his abilities in engineering were highly regarded.

At Bell Aircraft he was Project Engineer on a Navy experimental carrier-based fighter, the XFL-1.

In 1940 he went on active duty with Navy Bureau of Aeronautics as Assistant to the Head of the Armament Branch, Engineering Division. In 1942 he was made Assistant Head of the Experimental and Development Branch, BuAer, responsible for the program of aircraft and equipment design for Naval aircraft.

▶ **Heads BuAer Design Branch**—In 1943 Commander Burr was appointed Head of the Utility Training & Transport Design Branch of the Bureau of Aeronautics.

In this capacity he was responsible for the engineering and development of the Martin Mars, the Lockheed XR-60 Constitution, the Grumman JR2F-1 transport amphibian, the XNQ Fairchild primary trainer, the XSN2J North American carrier-based combat trainer, and the XJL-1 Columbia single-engined amphibian.

Following this tour of duty, Commander Burr was assigned duty at the Naval Experimental Station in 1946 as Superintendent of the Aeronautical Materials Laboratory, and in 1948, after acting as Director of the Naval Air Experimental Station from August, 1947, to May, 1948, he was made Director of the Laboratory.

I.A.S Sections

Baltimore Section

David P. Samson, Jr., *Secretary*

The Section's final meeting before the fall season was held June 24 under the chairmanship of the 1947–1948 Chairman, J. M. Jacobson. About 100 members were in attendance.

▶ **1948–1949 Officers Installed**—New officers for the next season were installed in office as follows: Chairman, O. J. Schaefer; Vice-Chairman, G. Trimble; Secretary, D. Covington; and Treasurer, R. Draut.

An Advisory Board of eight people was also announced. Elected for terms of 2 years, members of the board are: J. M. Jacobson; Capt. M. Welborn; F. D. Jewett; W. A. Bortner; F. Clauser; and H. C. Wieben.

Elected as Area Councilor was Prof. G. L. Bryan, Jr., of The Johns Hopkins University.

▶ **Engineering Debate**—A debate featured the proceedings of the evening. The question was: "Resolved: That Engineering Is Better Qualified Than Manufacturing to Control Production Design."

The Affirmative or engineering point of view was supported by Glenn Evans, Chief of Tool Engineering, The Glenn L. Martin Company while the Negative or shop point of view was taken by O. J. Schaefer, Assistant to the Vice-President—Engineering, also of the Martin Company. Result was unannounced by the Section.

Dayton Section

E. W. Robischon, *Secretary*

Dr. Hugh L. Dryden, Director of Aeronautical Research of the National Advisory Committee for Aeronautics, was the principal speaker at the Section's June 24 meeting at the Engineers' Club. Chairman A. A. Arnhym presided.

▶ **Three New Council Members**—The regular meeting was preceded by a dinner attended by 65 members and guests and by a short business meeting at which Chairman Arnhym announced nominations for three new council members to replace those who had left the Dayton area. New members elected were W. A. Barden, Albert B. Deyarmond, and Eugene B. Jackson, filling the vacancies left by Harrison C. Chandler, Jr., Col. Richard Gimbel, and Lt. Comdr. Harry J. Huester.

▶ **150 Hear Dryden**—Approximately 150 persons heard Dr. Dryden, who presented a paper on "Sixty Years of Experimental Supersonic Research."

Dr. Dryden traced the history of supersonic research from the early work of Ernst Mach in the late 1800's to the present. He pointed out that, although great emphasis was placed on the work done by the Germans in World War II, the United States had not lagged behind but also had produced several supersonic wind tunnels. One interesting facet of Dr. Dryden's talk was the description of the derivation of the term "Mach Number."

One of the earliest high-speed wind tunnels, the scientist said, had been built in Dayton at McCook Field in the 1920's.

In closing, Dr. Dryden briefly discussed the coordinated wind-tunnel development program of the Air Force, Navy, and N.A.C.A.

Hagerstown Section

J. Anthony Pauli, *Secretary*

The section held a meeting on June 9 at which Sam A. Gordon, Chief Test Engineer of The Glenn L. Martin Company was the speaker. Roy Lessard, Chairman, presided.

The subject of Mr. Gordon's talk was "Fatigue Testing of Components in Aircraft Structures."

▶ **Late Recognition**—Mr. Gordon stated that, before starting a detailed discussion of fatigue or low frequency repeated load testing, he thought it advisable to justify the apparent late recognition of the problem of fatigue in aircraft structures, whereas practically all other engineering fields show early recognition of the problem.

It was rare, Gordon said, that an airplane ever lasted long enough to disclose any fatigue characteristics, though they may have existed to a high degree. Also, structural design criteria involved conservative allowables and high load factors, so that when a plane flew at 1g, it could barely develop stresses greater than 10,000 to 15,000 lbs. per sq.in. in the parent alloys, whereas the endurance limit of such alloys hovered around 20,000 lbs. per sq.in.

Increased activity in the metallurgical field a few years ago gave an increased optimism in aircraft design, Gordon continued, resulting in higher design allowable, and lower design load, factors. Now we find the airplane continually flying at something equal to, or slightly above, the fatigue limit of the material itself.

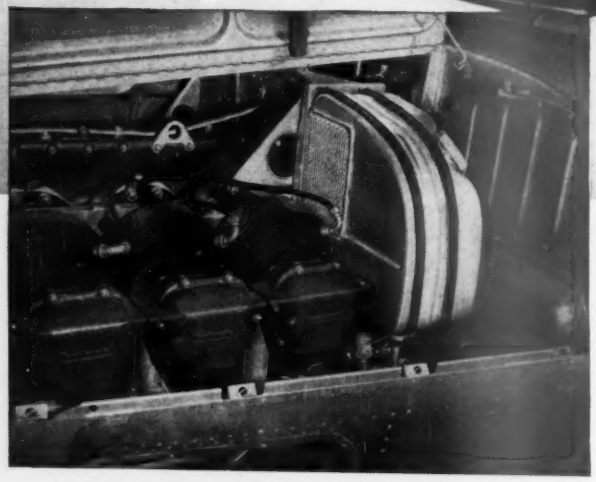
▶ **Causes for Fatigue Failure**—Gordon divided the causes for fatigue failures into three categories:

• Failures resulting from dynamic loads developed by resonance with accompanying amplitude in the component structure

VIDEO WAY STATION

Jointly developed by the Westinghouse Electric Corporation and The Glenn L. Martin Company, I.A.S. Corporate Members, this Stratovision station—a B-29 converted at $100,000 cost—rebroadcast telecasts of the Republican National Convention from an altitude of 25,000 ft. near Pittsburgh. Receiver antenna is atop the fin, while the huge transmitter mast is telescoped downward below the nose section. The flying television studio contains complete air-conditioning system developed by Martin and said to be first to be used successfully in any aircraft. Without air conditioning, cabin temperature with television equipment operating reaches 132° F.

Beechcraft Bonanza...



...has a FEATHER-WEIGHT in its "Cool-Tank"

The Beechcraft Bonanza (Model 35) All-Metal Four-Place Monoplane, a recent creation of Beech Aircraft Corporation, Wichita, Kansas, has a FEATHER-WEIGHT All-Aluminum Oil Cooler built into its Beech-designed "Cool-Tank".

The Beechcraft Bonanza is another of the growing numbers of modern aircraft that are taking advantage of the unique construction and accurate testing of FEATHER-WEIGHT oil coolers.

Light, strong and compact because their thin, all-aluminum sections are brazed with aluminum alloy, FEATHER-WEIGHT oil coolers offer maximum resistance to extremes of temperature, pressure, vibration and shear.

Testing in the largest, most modern wind tunnel laboratory in the aeronautical heat exchanger industry accurately predicts FEATHER-WEIGHT performance under actual flying conditions.

Inquiries concerning FEATHER-WEIGHT all-aluminum oil coolers are invited. CLIFFORD MANUFACTURING COMPANY, 573 E. First Street, Boston 27, Massachusetts. Offices in New York, Chicago, Detroit, Los Angeles.

CLIFFORD Feather Weight **ALL-ALUMINUM OIL COOLERS**

HYDRAULICALLY-FORMED BELLOWS HYDRON

where stresses are produced that exceed the design yield or ultimate values with subsequent set or fractures.

• Failures resulting from dynamic loading condition in the component which produces stresses that do not exceed the design values, but where local deformation progressively reduces the strength of the detail part in the composite structure, with subsequent permanent distortion or creation of an incipient failure.

• Failures resulting from any one of the many so-called "stress raisers" which affect the fatigue strength of a single machined unit or fitting when subjected to repeated loads.

Many attempts have been made to justify gust frequency probability studies with the number of cycles of load application at various load ranges, Gordon said. Investigators have tried to discuss this problem in terms of formulas, integrals, number of chord lengths of gusts, frequencies of occurrence, etc., but such is not all the case, at least for the present time, the speaker asserted.

▸ **More Latitude in Thinking**—It appears more advisable, he continued, to allow considerable latitude in fatigue thinking on air-frame structures. More emphasis should be placed on the designer's personal experience than on any available theoretical studies.

The simplest and correct way of discussing the cause of fatigue failures in composite structures is to label it "Bad Detail Design," Gordon said. Unfortunately, no method yet devised has proved as satisfactory as the fatigue test itself to disclose faulty design problems, so it appears that fatigue test procedure will continue to be used.

▸ **Landing Gear Failures**—Leaving the composite structures, Mr. Gordon discussed the landing gear and classified failures in the axle, the half fork, and cylinders as "element" failures.

Causes of failures in these elements are just as difficult to determine as in a composite structure, he said, and it is advisable to run fatigue tests as early as possible on prototype components in an attempt to disclose the most critical stress raiser.

Where 2,000–5,000 cycles might be satisfactory for 25,000 hours of life for composite structures, 20,000–40,000 cycles would be desirable for landing gears, the test engineer said.

▸ **Three Test Methods Used**—The Marin company has used three separate and distinct methods of fatigue testing in large aircraft structures:

• Load a surface with lead shot to some value slightly above load limit and determine tip deflection characteristics. Surface then is unloaded to 90 per cent of limit load and is oscillated by hand through the natural frequence of the complete assembly. Static deflection measurements then are correlated with the dynamic deflection measurements to secure the limit load value.

• Apply an external eccentric force with a given unbalance at the natural frequence of the unloaded specimen to produce the required limit load.

• Apply the static test loads through a hydraulic constant pressure system by way of a cycling machine, which was developed at the Martin company and is capable of applying pressures from 1 to 200 cycles per min. up to 3,000 lbs. per sq.in.

This latter method, used almost entirely by Martin, has the advantage of being able to cycle-test any assembly that was set up for structural test, providing the constant pressure system is used.

In conclusion, Mr. Gordon discussed some theoretical aspects of fatigue testing in which he stated that the only correlation between fatigue testing and the specimen itself, other than by experience, is to determine gust frequencies and values over the life of a large number of aircraft scattered all over the world.

Los Angeles Section

John C. Silliman, *Secretary*

A dinner and technical session were held June 10 with Willis M. Hawkins, Chairman, presiding.

The principal speaker of the evening, R. J. Shanks, Electronics Department, Hughes Aircraft Company, was introduced by "Bob" Reedy, Assistant Chief Engineer of Radioplane Corporation.

▸ **Guests from Argentine**—Two guests from the Argentine were present: Sr. Damingo Albano and Sr. Manuel Gutierrez of the Fama (Flota Aerea Mercante Argentina), Buenos Aires. In addition, Dr. A. Giffron of New York University was present.

Mr. Shanks' talk was concerned with radar techniques for commercial aviation.

▸ **Radar Definition**—Beginning with a simple definition of radar, he said that the system consists of sending out an R.F. signal from a station which is reflected back from any object the signal strikes. The total elapsed time of the wave is measured, and the distance to the object is calculated. To a certain degree, the strength of the echo indicates the size of the object.

In the second part of the talk, Mr. Shanks discussed the main features of radar, which he enumerated as follows: ranging, detection, direction, and a gross determination of quality of a target. He was quick to mention that the direction of a target cannot be ascertained too accurately and that sometimes it is hard to distinguish between a cloud and an airplane on the radar scope.

▸ **Radar Limitations**—Radar has limitations and can be thought of as a visual line of sight beam. It is not dependable for ranges of 500 miles or more.

Mountains and other physical obstructions are definite barriers to radar waves. Furthermore, as previously mentioned, it is difficult to interpret the image on the radar scope, the speaker said.

There also are several disadvantages when considering installation of radar in aircraft. Weight is a positive disadvantage, and in some instances antennas must be placed in positions that jeopardize the aerodynamic cleanness of an aircraft. Cockpit radar presentation is sometimes difficult because of bulk of instruments.

In the third portion of his talk, Mr. Shanks discussed the two formal classifications of radar: first, the "pulsed" radars, and second, the "frequency modulated" radars.

Radar units, Mr. Shanks said, can be either ground-based or air-borne and it is possible to have either primary or assisted types of radar. In the assisted type, the transponder beacon is used as a means of simplifying and broadcasting back to the sending station a new signal having a considerably higher level of energy than the original.

The speaker then covered different types of radar, such as mapping, tracking radars, some discussion of G.C.A. systems now in use, as well as I.L.S., the Loran system, and systems for communication and identification.

▸ **Application to Air Transport**—In closing, the application of radar to the air transport field was discussed. Of the many possibilities, Mr. Shanks believed the distance-measuring devices were headed for heavy development.

Other possible developments are:

• **Omni-range System**—Provide air-line pilots an automatic fix with several ground stations. This system is dependent upon a rotating radiating field that establishes aircraft direction from fixed ground position. A distance-measuring device would be used with the system, as well as a polar coordinating system that would enable the pilot to set a straight course between ground stations and to orbit accurately about a particular point, such as a terminal airfield.

• **Collision Warning**—The use of FM altimeters was discussed, Mr. Shanks expressing the opinion that collision warning devices could be installed to prevent air accidents.

• **Traffic Control**—Real payoff, the speaker felt, would be development of new and better traffic control systems. A new report, "Air Traffic Control," issued by the Radio Technical Committee for Aeronautics, Committee No. 31, has been issued, Mr. Shanks said, which outlines in a com-

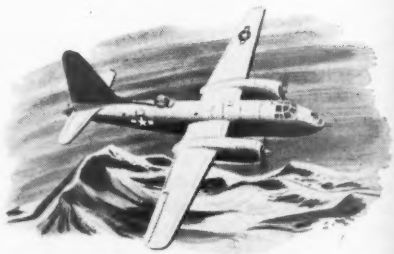
SHAKING THE TRUTH OUT OF A TURBINE BLADE

▶ Here a pair of electro-magnets is "shaking the truth out of a turbine blade." It is being *shaken* in this laboratory test to determine its true natural vibration frequencies—the dangerous frequencies that exist when a very small force causes a large deflection.

▶ The blade is oscillated by high frequency magnetic impulses. As the speed of the magnet excitation is increased, the blade is made to vibrate at its various natural frequencies. A photo-electric cell serves to locate these frequencies precisely, while a measuring microscope reveals the exact amplitude of each.

▶ Modern research such as this determines blade stamina in a much shorter time than would otherwise be possible and provides accurate data from which engineers can design turbine blades and many other vital aircraft engine parts that do not possess harmful vibration characteristics.

▶ Another example of the painstaking research behind the development of Wright aircraft turbine and reciprocating engines.



POWER FOR AIR PROGRESS

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prehensive manner the important elements of traffic control.

In conclusion, Mr. Shanks advocated close cooperation between electronics and aircraft engineers to effect worth-while radar aids to commercial air transport. Weight allowance and adequate space must be allowed for by the aircraft designers for radar; electronics engineers, on the other hand, must concentrate on making good use of space and weight alloted by providing radar scopes that are readily understood and analyzed by the pilot.

San Diego Section

Ralph H. Schick, *Secretary*

Meeting at the Marine Corps Officers Club June 17 under chairmanship of K. R. Jackman, Chairman—Meetings Committee, members heard two speakers: R. H. Vickerstaff, Public Information Office, The Pacific Telephone & Telegraph Company, Los Angeles; and L. G. Trolese, Electronics Engineer, Electronics Laboratory, U.S. Navy, San Diego.

▸ **Television Reception**—The subject of television was confined to reception in San Diego by the speaker, Mr. Trolese.

▸ **Microwaves**—Mr. Vickerstaff gave a comprehensive explanation of microwaves, accompanying his talk by actual demonstration of the transmission and receiver units.

San Francisco Section

R. T. Nilsen, *Secretary*

At the June 3 meeting held in the Hotel Claremont, Berkeley, Lawrence A. Clousing delivered a talk on "Flight Testing Near the Speed of Sound." Chairman Smith de France presided.

Mr. Clousing, who is chief of the Flight Research Section, Ames Aeronautical Laboratory, Moffett Field, introduced his talk by discussing pressures on a wing at subsonic, sonic, and supersonic speeds and explaining the presence of a line of discontinuity or shock wave at sonic and supersonic speeds.

▸ **Seeing Shock Waves**—Depending upon the position of the sun with respect to the aircraft, Clousing reported, shock waves at Mach Numbers of from 0.75 to 0.80 actually can be seen by a pilot. A slide of a photograph taken from the cockpit of a research plane revealed shock waves off the cockpit canopy and also simultaneously along the wing.

Special flight studies made by N.A.C.A. test pilots at high subsonic Mach Numbers have led to the establishment of valuable general precautionary rules for high-speed test flying, he said. In research flights at high speeds, safety has more than the usual significance. It means not only the safe return of pilot and plane, Clousing said, but the acquisition of data, which is the aim of the flight.

▸ **Outlines Safety Rules**—Mr. Clousing outlined safety rules as follows:

• **Precautionary Rule 1**—Initial flight tests at high subsonic Mach Numbers should be carried out at an altitude at which excessive air loads cannot result even though the plane is stalled.

• **Precautionary Rule 2**—At Mach Numbers above those at which local velocities on the wing exceed the local speed of sound, flight tests at progressively higher Mach Numbers should be undertaken only in small increments and only after exploring accelerated flight characteristics at lower numbers.

• **Precautionary Rule 3**—There should be accurate recording and analysis of essential data as tests progress (corollary of Rule 2).

Illustrative slides were used in discussing each rule in turn. Clousing stated that adherence to Rule 1 is advisable, because at high Mach Numbers inadvertent pitching and even stalling may occur. Based on a representative assumption of wing loading and maximum lift coefficient for a typical fighter, a load factor of about 19 is aerodynamically possible at sea level and at a Mach Number of 0.85, while a load factor of less than 6 is possible for the same assumptions at an altitude of 27,000 ft.

With regard to Rule 2, Mr. Clousing said that experience has shown that, at some number above the critical Mach value of the wing, flight at higher Mach Numbers may be either structurally unsafe, uncontrollable, or both. He then outlined buffet boundary and maneuver limitations, explaining various aerodynamic hazards encountered, such as nosing-down tendencies, large changes in stick-force gradient, transonic flutter, tail surface buffeting, and wing shock stall.

Washington Section

M. B. Ames, Jr., *Secretary*

Fifty members, meeting June 9, heard E. G. Stout, Consulting Engineer, Consolidated Vultee Aircraft Corporation, on "Airplane Model Testing by Radio Control." Chairman Ivan H. Driggs presided.

▸ **Dynamic Model Testing**—Mr. Stout gave a discussion, illustrated by slides, on the development of a dynamic airplane model-testing technique using radio control.

In addition to giving the history of the development, he described in some detail the characteristics of the engines and control equipment. The technique has been applied almost exclusively to date in the development of the water characteristics of seaplanes and flying boats.

At the conclusion of his talk, Mr. Stout presented motion pictures showing further details of the equipment and its operation during actual remote-control model tests of flying-boat designs.

Student Branches

Academy of Aeronautics

A British film, *University of Flying*, was shown at the June 23 meeting, with Chairman John Korbuszewski presiding.

The film showed the activities of men attending a test-pilot school. The school is specifically designed to produce test pilots for aircraft companies.

Training at the school covers a period of 9 months, which is divided into two phases: classroom theory and flight testing. The school is at present open to pilots throughout the world. Entrance requirements are high, therefore enrollment is low.

Aero Industries Technical Institute

Guest speaker at the June 2 meeting was Ralph Martin, Lubrication Engineer, Union Oil Company, who spoke on "Manufacture of Lubricants and Fuels for Aircraft." Bruce McIntyre, Branch Chairman, presided at the meeting attended by 15 members.

Mr. Martin described how and from what deposits crude oil is obtained and the different processes used in refining it. He also spoke on the problems encountered in lubricating jet engines which result from the intense heat generated and pressures developed.

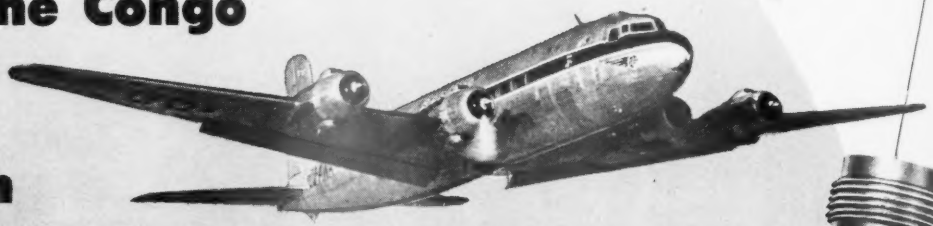
Aeronautical University

At the June 22 meeting attended by 76 members, three amendments to the Constitution were discussed. Chairman Mielke, of the Constitution Committee, read the proposed amendments.

BG spark plugs fly

from New York

to the Congo



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Belgian Airlines

Modern airliners, cruising at 300 miles an hour, span the trans-Atlantic route from New York to Brussels for SABENA* Belgian Airlines. The same high-speed airliners fly from Brussels to Leopoldville, capital of the Belgian Congo, and from Leopoldville to Johannesburg in the Union of South Africa. In this long-distance service, BG Spark Plugs are again demonstrating their well-known dependability.

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SERVING WORLD AVIATION OVER THIRTY YEARS

In addition, a vote was taken to have a regional Student Branch meeting, proposed by the Notre Dame Student Branch, in the fall.

Chairman A. C. McDermott presided.

Air Force Institute of Technology

A new Student Branch has been formed in the A.F.I.T. with Prof. Gunther R. Graetzer, Head of the Department of Aeronautics, as Faculty adviser. Captain Prentice B. Peabody of the 1949 Class in Engineering is the first Chairman.

The initial meeting was devoted to "Guided Missiles and Their Future," which was covered by Major R. F. Stemen and R. O. Wickersham of the Air Launched and Surface Launched Missiles branches, respectively.

University of Southern California

Organization of this Student Branch has taken place with the following officers elected: Honorary Chairman, Roy V. Smith, Faculty Member; Chairman, Derry D. Noisom; Vice-Chairman, Robert E. Williams; Secretary, John E. Siebel III; and Treasurer, John B. Strigle.

Spartan College of Aeronautical Engineering

At the June 10 meeting, Otto Kirchner, Chief Engineer, American Airlines, spoke on "Airline Maintenance" before 75 members. Chairman Gene Hess presided. Mr. Kirchner described proper maintenance on aircraft and what is expected of aeronautical and maintenance engineers.

News of Members

Frederick W. Anderson, former Douglas Aircraft Stress Engineer, has been named Research Engineer, Northrop Aircraft, Inc.

Harold E. Baughman resigned as President, Aero Publishers, Inc., to accept the post of President and General Manager, Aviation Sales Corporation.

Samuel M. Berkowitz is Research Engineer with Franklin Institute. He had been Chief Engineer and Works Manager, Management & Research, Inc.

Murray I. Brill is Aeronautical Engineer with Frank Mayer & Associates, having resigned from North American Aviation, Inc.

James E. Broadwell, former Assistant Professor of Engineering Thermodynamics, A. F. Institute of Technology (Wright Field), is at the University of Michigan as Instructor.

William E. Brown resigned as Project Engineer, Bell Aircraft Corporation, to become Assistant Project Engineer, The Glenn L. Martin Company.

John D. Brueckner, former Flight Test Engineer, Consolidated Vultee Aircraft, has been named Chief Engineer, Van Dyke Instruments, Inc.

Eugene J. Dugan, Jr., is Stress Analyst, Consolidated Vultee Aircraft Corporation. He had been Structures Test Engineer, Beech Aircraft.

George J. Egner, Jr., former Globe Aircraft Corporation Aeronautical Engineer, is now Instructor of Airplane Design, Aeronautical University, Inc.

William K. Foulke is Power Plant Engineer with Northwest Airlines, Inc. He was Project Engineer, Aeronautical Ice Research Laboratory, Smith, Hinchman & Gryllis, Inc.

George L. Frame resigned as Junior Engineer, Development & Installation, Lester D. Knight & Associates, to become Senior Detailer, McDonnell Aircraft Corporation.

Valerian N. Gartseff is Head of Structures Section, Experimental Department, U.S. Naval Air Station, Lakehurst, N.J. He was Structures Project Engineer, Republic Aviation Corporation.

Welko Elton Gasich, former Flight Test Engineer, N.A.C.A. Ames Aeronautical Laboratory, and CalTech student, is Aeronautical Engineer, Douglas Aircraft Company, Inc.

Douglas A. Gilstad is Aeronautical Research Scientist, Langley Memorial Aeronautical Lab, N.A.C.A. He had been with Curtiss-Wright Airplane Division as Unit Head, Structures.

George P. Goodman has been appointed an Aeronautical Engineer at Langley Memorial Aeronautical Laboratory, N.A.C.A.

Robert F. Havens has joined Air Materiel Command, Wright Field, as Aeronautical Development Engineer. He was with N.A.C.A.'s Langley Memorial Aeronautical Laboratory as Junior Aeronautical Engineer.

Edward B. Heyl is Air Safety Investigator, C.A.A.; he was former Research Engineer, Aero Insurance Underwriters, Inc.

Frederick L. Holman resigned from Foster-Wheeler Corporation as Layout Draftsman to take post of Engineering Drawing Checker, Fairchild Aircraft Division, Fairchild Engine & Airplane Corp.

Philip E. Jockle, Jr., former North Carolina State College Aeronautical Engineering Student, is Junior Engineer, University of California.

Robert W. McJones is Aerodynamicist at Douglas Aircraft Company, Inc. He is former Graduate Student and Assistant Instructor, CalTech.

Robert A. Mendelsohn is at Curtiss-Wright Corporation (Columbus Plant) as Research Aerodynamicist. He had been Head of the Aerodynamics Department, Continental Aviation Corporation.

Paul W. O'Meara resigned as Consultant, Standard Register Corporation, to take post as Production Design Engineer with Curtiss-Wright Corporation, Columbus Plant.

Thomas G. Preston, former Technical Assistant, British European Airways, is now Engineer, Prenco Progress & Engineering Company, Canada.

John L. Reynolds has been named Vice-President, Jack & Heintz Precision Industries, Inc. He is Manager of the Aviation Division.

James A. Sansonetti is Draftsman, Equipment Department, The Glenn L. Martin Company.

Felix W. Saunders resigned from Consolidated Vultee Aircraft as Head, Data Reduction & Analysis Section, to become Project Supervisor, G. M. Giannini & Company, Inc.

John C. Schroeter is Comptroller, Headquarters, Military Air Transport Service, Washington, D.C.

Peter Serrell, formerly on the design staff of the Southern California Cooperative Wind Tunnel, has joined with William A. Sandberg, formerly Chief Engineer, Lacy Manufacturing Company, to form the Sandberg-Serrell Corporation, a consulting and design group with headquarters in Pasadena, Calif.

Richard G. Steuer is Vibration Field Test Engineer, Propeller Division, Curtiss-Wright Corporation. He had been a staff member of M.I.T.'s Flutter Research Laboratory.

Howard C. Tinney, former Graduate Student, University of Michigan, is with Boeing Airplane Company as Aerodynamicist.

Robert W. Wagner is a draftsman with Kollsman Instrument Division, Square D Company.

Robert D. Wallace resigned as Aero. Computer with Lockheed Aircraft to become Aerodynamic Flight Test Engineer, North American Aviation, Inc.

Ida L. Warren resigned from Piasecki Helicopter Corporation and is Assistant Design Engineer, assigned to helicopter research, McDonnell Aircraft Corporation.

Jerome Weissman is Flight Test Engineer, Consolidated Vultee Aircraft.

William R. Witt, Jr., is Graduate Student in Applied Mechanics and part-time Instructor in Aeronautical Engineering Department, Virginia Polytechnic Institute.

Harry Woodhead, recently President of Consolidated Vultee Aircraft Corporation, and prior to that one of the leading executives in the pressed steel products business in this country, has joined the Douglas Aircraft Company, Inc., as General Manager of the new Metal Products Division.

Henry W. Woolard resigned as Assistant Professor of Aeronautical Engineering, West Virginia University, to become Aerodynamicist, Cornell in Aeronautical Laboratory.

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Necrology

Raymond Ernest Dowd

Raymond Ernest Dowd, Associate Fellow of the I.A.S., died July 13, at the age of 61. He was Chief Engineer at the Aero Division, The Russell Manufacturing Company, Inc., and President of the Trumatic Company of Chicago.

▶ **Active in Aviation Since 1910**—Mr. Dowd early took an interest in aeronautics, building models in 1910 and building and flying a glider, largely of his own design, in 1911.

Continuing his glider experimental flying in 1912, he organized and was President for several years of the Aero Club of Springfield, Mass.

Born June 30, 1897, in Springfield, he was educated in the Springfield Technical High School, where he was graduated in 1916.

In 1917 he tried to enlist in the Aviation Section of the Army Signal Corps but was rejected because of ear trouble. He then took a position with Thomas Morse of Ithaca, working on production and engineering until about 1922. During this time he organized and was President of the Aero Club of Ithaca.

Mr. Dowd designed and helped build the first streamlined enclosed coupe body on the Paige 6-66 chassis for W. T. Thomas in 1922, and the next year he joined the American Bosch Magneto Corporation of Springfield, Mass., where he was in charge of design and engineering of Bosch automotive accessories.

▶ **Joined Russell Mfg. in 1928**—Leaving the Bosch firm in 1928, Mr. Dowd joined the Russell Manufacturing Company in the capacity of Chief Engineer of the Aero Division, located at the New York Branch.

In 1931 he transferred to Chicago, where he also added to his duties that of Manager of the Equipment Division. It was in Chicago that he was named President of the Trumatic Company, which is engaged in engineering developments of aircraft parts and accessories.

Leon Beskin

Leon Beskin, Head of the Supersonic Aerodynamic Section, Bureau of Aeronautics, Navy Department, died suddenly while at work July 9. He was 37 years old.

▶ **Educated in Paris**—Mr. Beskin, who came to this country from France in 1941, was born December 22, 1911,

(*Continued on page 102*)

Air power is peace power

On Air Force Day, Sept. 18, Lockheed Aircraft Corporation salutes the men who fly to keep America strong.

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An Expanding Institute

A widely accepted astronomical theory, based on Edwin Hubble's brilliant studies of the movements of certain galaxies, postulates that our universe is expanding at the rate of many light-years per year. The Institute of the Aeronautical Sciences cannot keep pace with the universe, but it certainly is expanding. On this page (top and bottom) are architects' sketches of the new buildings that are presently going up to house ever-growing I.A.S. activities. *Top:* The Los Angeles Facility for which the contract was signed August 6. *Below:* The San Diego Facility, which should be under way by the time this issue goes to press.

Editorial

For Services Rendered—

With the approach of the end of our fiscal year (30 September) we have been keeping an eye on our "how-gozzit" chart to see how we are doing and what the trends for the next fiscal period may be. By and large—and considering the times—what we see is not at all discouraging.

The Institute does not exist for the purpose of making money. It is here to serve the interests of its members in advancing the art and science of aeronautics in America. The Officers and Council are committed to a program of rendering the greatest possible service with the funds at our disposal. In all modesty, we believe we are doing just that.

A glance over the period since we last closed our books shows a favorable balance on the side of services rendered. Our national meetings have been notable for the quality of the programs—and have been the largest in our history. Our first international meeting was highly successful in all aspects. Section meetings in all parts of the country have increased in number and in importance. Our monthly publications have been steadily improved and expanded. The new I.A.S. reprint and preprint service was instantly popular with our members. I.A.S. libraries, both East and West, are rendering highly important services to industry in keeping engineers posted on current aeronautical literature from all over the world.

In stepping up our "flight speeds," we have been watching our "specific fuel consumption" very carefully. We have been trying to maintain a balance between costs of services rendered and the cost to members in the form of annual dues. So far, we have not been doing too badly. As you know, we ended our 1947 fiscal year "in the black" by a narrow margin. Now, however, the trends of the times are catching up with us. All the things we buy—printing, travel, materials, and personal services—have been rising steadily over the past 12 months. Whether we like it or not, we, too, have been caught in the inflationary spiral, and the "range" vs. "fuel consumption" curves of the "how-gozzit" are now divergent and are trending farther apart for the coming year.

The I.A.S. Council has given the problem its most serious attention for the past several months. A number of plans were studied, and all those that seemed to yield any possibilities for improvement of the situation were explored. It was apparent, however, that I.A.S. services were being rendered at somewhat less than actual cost, and it was reluctantly agreed that a small increase in membership dues was not only justified but necessary to ensure break-even operations for the coming fiscal year.

As will be seen from the following table, the increase is small. I.A.S. dues in all grades are still far below those of other comparable technical societies.

Fellows	$16.50
Associate Fellows	$16.50
Members	$13.50
Associate Members	$13.50
Technical Members (age 26 and over)	$13.50
Technical Members (under 26)	$ 6.50
Student Members	None

With these changes, coupled with a new and more rational scale of Corporate Member dues adopted by the Council at the same time, your Institute will not only be able to maintain the services it now renders but will be able to go forward to keep pace with the rapidly expanding requirements of the aviation industry in the years ahead.

S. P. J.

Annual Summer Meeting Dinner, Institute of the Aeronautical Sciences, Hotel Ambassador, Los Angeles, July 16, 1948.

Highlights of Technical Sessions at Annual Summer Meeting

Opening Session, July 15

By
John C. Silliman
Secretary, Los Angeles Section

THE OPENING SESSION of the recent Annual Summer Meeting held by the Institute of the Aeronautical Sciences in Los Angeles brought to light some interesting developments in the field of aircraft structures.

In the never-ending search for lighter and more efficient aircraft structures, the stress analysts have been faced with more complex problems, the answers to which can be obtained only through constant test and rigorous theoretical research. The simple equations and theories that were used when aircraft was in the embryonic stage are not acceptable for refined analysis of the more complex structures in present-day aircraft. As the complexity increases, analysis by the use of simplifying assumptions and short-cut methods is used less and less. The solutions oftentimes are reached through the tedious and time-consuming breakdown of several simultaneous equations or through a better insight in the behavior of the structure under load and oftentimes through the use of the efforts of men who have already looked into the problem and arrived at the solution or the means whereby the solution can readily be reached.

Flutter problems are important both to the aerodynamicist and to the stress analyst. The solution to this problem is complex, requiring the use of more and more powerful mathematical methods.

The three papers given in the morning session concerned in part the above problems facing today's aircraft engineer. The subject of the paper given by P. A. Dennis and D. G. Dill, of Douglas Aircraft Company, Inc., was "The Application of Simultaneous Equation Machines to Aircraft Structure and Flutter Problems." Mr. Dill pointed out that the use of automatic computers is playing a greater role in solving the increasingly difficult mathematical problems that

modern aircraft engineering is encountering. The particular automatic computer described is one built by Douglas Aircraft for solving up to four linear simultaneous algebraic equations with as many unknowns. It is manual and reversible; the operation consisting merely of setting dial knobs at the values of the coefficients in the equations and then adjusting other knobs representing the unknowns until the system balances. Basically, the computer is the electrical analogue type where certain physical quantities in the computer are used to represent the numbers involved.

The accuracy of the solution is dependent to some degree upon the nearness to singularity of the set of equations but is, however, for most cases sufficient for the usual engineering requirements.

The chief advantage of the computer over the conventional methods of calculation is in the great saving of time, and it permits great flexibility in examining the effect of various parameters.

The use of simultaneous equation machines is not limited to aircraft structure and flutter problems but can be applied to many of the problems in divergence and control surface reversal or in almost any field in which simultaneous linear equations must be solved.

The subject of the paper given by Dr. N. J. Hoff, of the Polytechnic Institute of Brooklyn, was "The Shear Stress Concentration and Moment Reduction Factors for Re-enforced Monocoque Cylinders Subject to Concentrated Radial Loads."

In the minds of many stress analysts the struggle between common sense and time-honored methods of calculating bending moment distribution and shear distribution in ring frames subjected to concentrated loads has long posed a problem. In the investigations carried out in the last few years it has been proved that the conventional methods of stress analysis for maximum bending moment and moment distribution in a ring frame of a re-enforced monocoque cylinder subjected to a concentrated radial load are not valid. The more rigorous analysis makes no use of the customary simplifying assumptions, and the results show good agreement with the anticipations based on good common sense. Surprising as it may seem to many engineers who were inclined to favor the common-sense analysis, the maximum shear stress concentration occurring in the sheet covering the monocoque structure in the vicinity of the concentrated load is often ten times as large as that calculated by elementary methods and the maximum bending moment in the ring can be as low as one-third that given by the conventional method.

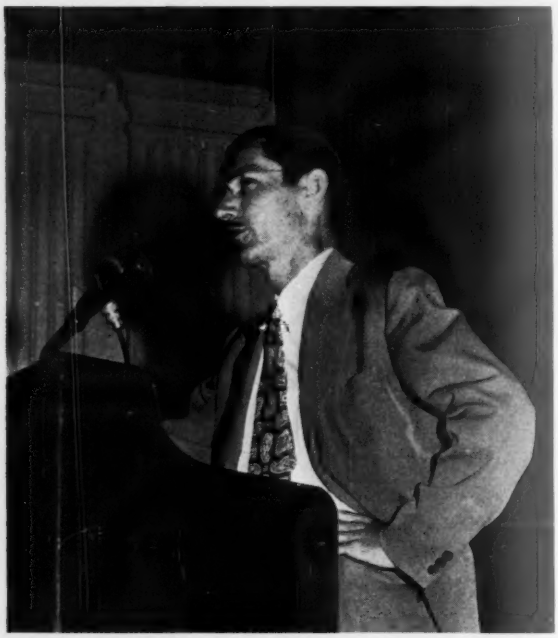
Nicholas J. Hoff, Professor, Aeronautical Engineering, Polytechnic Institute of Brooklyn.

P. A. Dennis, Chief, Engine Laboratory, Douglas Aircraft Company, Inc.

Tests conducted by the N.A.C.A. and by the Polytechnic Institute of Brooklyn give reasonable verification to the theory.

Dr. Hoff presented a series of graphs of value to the aircraft structures engineer. Although many of the present-day aircraft rings or frames and their loads may not be too similar to conditions investigated by Dr. Hoff and his colleagues, the graphs will give the engineer a better insight into what to expect in moment and shear distribution problems.

F. R. Shanley, Consulting Engineer and Lecturer at the University of California at Los Angeles, spoke on "The Principles of Structural Design for Minimum Weight."



F. R. Shanley, Consulting Engineer and Lecturer, University of California at Los Angeles.

Mr. Shanley demonstrated the use of structural index charts as a means of determining the lightest practical arrangement of material which will transmit loads through specified distances. The use of these charts eliminates much of the tedious work that must be done to arrive at a least weight design.

The paper titled "Principles of Optimum Structural as Applied to Aircraft Weight Analysis" gives the results of the investigation by Douglas Aircraft into this problem. The subject matter contains information on such structures as (1) simple columns, (2) wide columns of the sheet-stiffener type, (3) compression panels, and (4) stiffened and unstiffened circular cylinders in bending.

The great value of the structural index is that it eliminates the effect of size in dealing with allowable stresses.

Metallurgy, Automatic Controls, New Seaplane Hull Design Treated at July 15 Afternoon Session

By
Randolph Hawthorne
News Editor, Aeronautical Engineering Review

THE JULY 15 AFTERNOON SESSION of the Annual Summer Meeting produced three highly interesting discussions of modern aeronautical progress ranging from basic metals employed in aircraft design, to the near-human, automatic mechanical "brain-and-brawn" controls which aid or take over flight responsibilities, and concluding with a description of tests of an improved hull design for seaplanes.

Citing 75S zinc-magnesium bearing aluminum alloy as the foremost accepted metallurgical contribution of the past decade, having greater load-carrying capacity than the older 24S copper bearing alloy, Leo Schapiro, Metallurgical Engineer, Testing Division, Douglas Aircraft Company, Inc., reviewed developments of the past and drew attention to some present metallurgical developments that can mean new construction metals in the next decade.

Two new metals were described which should be interesting to aircraft designers: molybdenum and titanium. These two metals, ductile in their pure form, contain properties different from the construction metals available to date.

With its elastic modulus approximating 50×10^6, its relatively good formability, and the outlook for strengths above 100,000 lbs. per sq.in. by means of alloy additions, the metal molybdenum, Schapiro predicted, will receive considerable attention from aircraft designers in the next decade.

Titanium merits attention, he said, on the strength of its being the fourth most plentiful metal and also for its elastic modulus and density, which is intermediate between aluminum and steel. Alloy developments with this metal likewise may be expected to produce high strengths useful to the aircraft designer.

The second paper, "Application of Servo Systems," by J. R. Moore, North American Aviation, Inc., dealt with so-called "intelligent" machines, control systems with "brains" and "nerves" as well as "sinews," which even now are trusted servants of pilots, engineers, and traffic controllers who operate our commercial and military establishments. They are variously called automatic pilots, automatic engineers, propeller synchronizers, automatic pitch controllers, automatic navigators, automatic approach and landing systems, and control actuator boosters.

Where the primary use of an automatic pilot today is to stabilize the aircraft and maintain a desired heading, developments now under way forecast the time when an aircraft can, if desired by the pilot, take off, climb at an optimum rate, fly at an optimum speed over any desired course, approach its destination, and land in a crowded traffic pattern without any assistance whatsoever from its crew.

Furthermore, Moore said, such a flight will be performed more rapidly, safely, efficiently, and smoothly in all weather conditions than can presently be accomplished by human pilots under the most ideal conditions of weather and traffic.

Following these and other introductory remarks, Moore explained the basic ideas of a servo system, translating much of the mumbo-jumbo of the present-day servo cult into somewhat less mystic English and describing briefly present popular methods of design, their pitfalls and limitations. He concluded with an indication of the probable trend of future developments.

Future improvements in the servo art are expected to take the following forms:

(1) Development and use of computing machines, including dynamical analogues for use in the laboratory; digital computers for the investigation of a large combination of parameters in complicated, multiple-coupled systems; engineering aid computers for handling special servo problems.

(2) Development of techniques for synthesizing multiple-coupled systems. In its present state, servo art has concentrated on techniques for handling systems with one desired input and one desired output. There are, however, an increasing number of servo applications involving several inputs and outputs, of which a complete automatic pilot is an example.

(3) Development of techniques for minimizing disturbances—the missing link of the precision servo field.

(4) Improvements in linear synthesis.

(5) Combination open cycle-closed cycle systems.

Of particular interest in the design of high-performance water-based aircraft is the high length-beam ratio hull, subject of the paper by Arthur W. Carter, of the Hydrodynamics Division of the Langley Aeronautical Laboratory, N.A.C.A., final presentation of the Session.

Extreme warping of the forebody planing bottom, together with an increase in hull length-beam ratio from 6 to 15, resulted in appreciable reductions in aerodynamic drag and hull weight and was markedly superior to conventional length-beam ratios for rough water operation, N.A.C.A. found in tests on a series of related seaplane hulls having a wide variation in length-beam ratios.

Hulls were designed to have similar resistance and spray characteristics for the same gross weight and to be physically interchangeable on a hypothetical seaplane design.

Hull volume was reduced 28 per cent and the frontal area was decreased 42 per cent when the length-beam ratio was increased from 6 to 15.

The hypothetical seaplane design was a twin-engined propeller-driven flying boat having a design gross weight of 75,000 lbs., a wing loading of 41.1 lbs. per sq.ft., and a power loading of 11.5 lbs. per b.hp. for take-off.

The hydrodynamic qualities determined in the investigation were the longitudinal stability during take-off and landing, spray characteristics, take-off and landing behavior in rough water, and the take-off performance.

In addition to the general conclusion that high length-beam hulls having low aerodynamic drag and reduced structural weight have acceptable hydrodynamic qualities and are markedly superior to conventional hulls for rough water operation, N.A.C.A. found that longitudinal stability of the basic hull having a length-beam ratio of 15 during take-off and landing and the take-off performance in smooth water were satisfactory and did not differ greatly from the same qualities of the related hull having a length-beam ratio of 6. An increase from 6 to 15 length-beam ratio appreciably reduced the maximum vertical accelerations during landings in rough water but resulted in an increase in angular accelerations.

Extreme warping of the forebody planing bottom of the hull having the length-beam ratio of 15 increased the longitudinal stability during take-off and landing in smooth water and considerably reduced the spray entering the propellers and striking the flaps, although the take-off time and distance were slightly greater than those of the basic hull. Warping the forebody resulted in large reductions in maximum vertical accelerations during landings in rough water but did not appreciably affect the motions in trim and rise.

A 45 per cent increase in length of afterbody of the high length-beam ratio hull resulted in a slight improvement in the longitudinal stability during take-off but increased the volume of spray entering the propellers. Extending the afterbody appreciably reduced the maximum accelerations and motions during landings in rough water.

Combining the warped forebody and extended afterbody on the high length-beam ratio hull made it possible to realize the improved characteristics of the two previous modifications. Longitudinal stability during take-off was increased when compared with the basic length-beam ratio of 15, and bow spray characteristics in both smooth and rough water were similar to those of the hull having the warped forebody.

Warping the forebody and extending the afterbody resulted in the minimum accelerations obtained during landings in rough water of any of the high length-beam ratio configurations.

The combination of warped forebody and extended afterbody on the length-beam ratio of 15 resulted in a 67 per cent reduction in the maximum vertical accelerations and a 50 per cent reduction in maximum angular accelerations when compared with the conventional length-beam ratio of 6.

Pilots' Flight Symposium

In a session on July 15, which unfortunately had to be a closed meeting for security reasons, some of the foremost test pilots of the West Coast produced what might be likened to a "tempest in a cockpit" by demands for radical changes in supersonic aircraft cockpit design and simplification of equipment to free pilots from present encumbrances.

Principals in the discussion were J. Towle, Lockheed Flight Test Pilot, who spoke on "Crew Escape Methods and Ditching of Large Aircraft"; Russell W. Thaw, Engineering Test Pilot, Douglas Aircraft—"Crew Escape Methods in Small Aircraft"; "Gene" May, Douglas (El Segundo) Flight Test Department—"Problems of Flight at High Altitude"; Marvin Michael, Boeing Flight Test Department—"Cockpits for Large Aircraft"; Robert Chilton, North American Aviation Chief Test Pilot—"Maneuverability of Bomb-

"Gene" May, Test Pilot, Douglas Aircraft Company, Inc.

ers and Fighters at High Altitudes"; and Dr. C. F. Lombard, University of Southern California, who gave a prepared aeromedical discussion. W. C. Rockefeller, Consolidated Vultee Aircraft Corporation, gave a prepared engineering talk.

Colonel C. A. Shoop, Hughes Aircraft Company, and commanding officer of a California Air National Guard fighter group, presided as Chairman. Introductory remarks were made by Robert Brush, Douglas test pilot, who warned that, until more thought is given to designing the speed-machine for the man, progress may be retarded in obtaining unlimited speed.

Elaborating on this theme, Test Pilot "Gene" May, who has been closely connected with development of the D-558 Skystreak and other high speed craft, declared that "Pilots of the future can't be crammed into a narrow enclosure with no space to spare."

Because of his cramped position in the Skystreak, he said, he was blind to an area beneath him 50 miles in diameter.

"On every flight in the Skystreak I was on instruments," May declared. Also, formation of frost on the canopy and an awkward arrangement of the instruments made it doubly tough, he added.

Enumerating the mass of encumbrances that force a flier "to look cross-eyed if you want to see out," he urged:

- That the flier's basic burden be lightened by the incorporation of automatic pilots, now available, to minimize buffeting and instability encountered in passing through the range of critical Mach Numbers and to furnish routine control.
- That cockpits be pressurized to obviate the clutter of personal oxygen equipment.
- Marked revision in cockpit design to give visibility.
- Simplified instrumentation for one-glance reading.
- Incorporation of small speed-retarder flaps for high altitude emergencies and for landing approaches.
- Cockpit designed as a "one-push" button cell in which a pilot could leave his craft in an emergency.

"All stabilizing chutes, slow-down devices, seat ejection, and opening of the pilot's parachute should be automatic and beyond the pilot's control," May said, before supersonic research planes can become successful combat types. He also suggested that fins be added to such a cockpit cell and that the cell be adequately pressurized and fitted with controls to make it essentially a plane within a plane.

Pilot Russ Thaw, who delivered a prepared discussion by Max Stanley of Northrop Aircraft, also called for a self-contained, jettisonable cell that would comprise the cockpit and limit the pilot's necessities to a G-suit, microphone, and writing pad.

"A pilot certainly can't do his best when encumbered with a heavy crash helmet, vision-limiting, uncomfortable oxygen mask, emergency bottle, and regulator," he said. In addition, he went on, there is the shoulder harness and belt, parachute, rubber vest for jumping over water, connections for radio headset, and G-suit, not to mention goggles, gloves, boots, microphone, and writing pad.

"These are crowded into a tiny cockpit already crammed with instrumentation, controls and gadgets—and in the middle is the pilot," Thaw said.

Among his recommendations for easing the pilot's burdens and increasing safety in high speed flight were:

- The oxygen supply should be attached to the pilot's person rather than to the plane.
- High-speed aircraft now being developed should be provided with aerodynamic air brakes to slow the plane to a safe speed for pilot ejection.
- Downward ejection through the cockpit floor should be incorporated in design of the cockpit to reduce ejection shock hazard.
- Cockpit pressure differential should be increased to a cabin pressure of not more than 12,000 ft. with the aircraft at 40,000 ft.

It apparently was the opinion of the pilots and Dr. C. F. Lombard, who is aeromedical research authority at University of Southern California, that the chances are good for a flier's survival with the proper design of specialized cockpits and escape devices to meet emergencies involving structural failures at extreme speeds at very high altitudes.

A free-fall escape from altitudes considerably above 40,000 ft. should be possible, Dr. Lombard declared. There are even some indications that a pilot might survive a free-fall escape from as high as 60,000 ft.

One of the major problems of high-speed pilotage, Dr. Lombard said, is "psychological stress." He recommended that, in the interests of flight safety, new attention be given to the pilot by reducing the complexity of his flying duties and increasing his comfort.

Morning Session, July 16

By

T. J. Venator

Engineering Representative, Aviation Gas Turbine Division, Westinghouse Electric Corporation

MILTON CLAUSER, a member of the Program Committee, opened this session and in turn introduced R. P. Kroon, Manager of Engineering, Aviation Gas Turbine Division, Westinghouse Electric Corporation, who functioned as chairman for the session.

Mr. Kroon then introduced Lewis G. Dunn, Jet Propulsion Laboratory, California Institute of Technology. The title of Mr. Dunn's talk was "General Status of Work at J.P.L." Mr. Dunn began by stating that the main portion of his talk would be devoted to the basic fundamentals of rocket motors and their design and a discussion of the various types of liquid rocket fuels, followed by a few comments on their activities concerning ram and pulse-jet type of engines. Because of security reasons it was stated that there would be no discussion of the solid type fuel for rocket motors.

Mr. Dunn then explained the basic formulas for derivation of rocket motor thrusts. From this stage the discussion led into general problems of rocket motor design and several different methods of cooling the rocket motor walls. Because of the excessive temperatures that are experienced in combustion chambers with presently available materials, it is impossible to operate a rocket motor without cooling. Depending upon the type of liquid fuel being used, one of the components is generally circulated or injected along the walls to maintain wall temperatures within acceptable limits. There are three general types of wall cooling: (1) a double wall construction in which part of the fuel is circulated between the walls before injection into the combustion chamber; (2) construction of the inner wall of the combustion chamber of a porous material so that the fuel cools the inner wall as it passes through to the combustion chamber; and (3) film cooling, in which a portion of the fuel is injected radially into the combustion chamber through a large number of small drilled passages, after which the fuel follows along the wall during the burning process. There were also several statements regarding the choice of fuels, and it was pointed out that the density has a noticeable effect on range or duration of operation.

In the second portion of Mr. Dunn's talk, he explained that the work being conducted at J.P.L. with regard to ram-jet engines has been of a basic nature involving combustion, as well as turbulent flame, studies. Several slides were shown showing the effects of combustion chamber pressure on burning patterns. Basic work is also being conducted on flame holders as required for jet engine combustion chambers.

As the result of the nature of the work that the Jet Propulsion Laboratory is conducting, Mr. Dunn requested that there be no open discussion regarding this project.

Louis G. Dunn, Jet Propulsion Laboratory, California Institute of Technology, Chairman of Opening Session.

The second discussion of the morning was given by Dr. J. F. Manildi, Assistant Professor at the University of California at Los Angeles, and Director of Research, G. M. Giannini & Company, Inc. Dr. Manildi's talk was titled "Testing of Jet Propulsion Engines Under Simulated Air Speed and Altitude Conditions." The speaker prefaced his remarks on this subject by saying that he was certainly no expert on this subject but that he would attempt to give some of the important factors on this subject and a few comments on the work that is being conducted at the Giannini company.

It is impossible to give a series of performance data on a jet engine which will fully describe its operation in any installation. The output from any jet engine is greatly influenced by contributing factors in the air-frame design such as inlet duct, cooling air losses, and general air-frame construction. As a result, the actual realized performance of an engine in an airplane will vary considerably, depending upon the type of installation. It was pointed out, however, that one of the best common denominators of engine performance is the simple formula of gross thrust, which is the product of the mass passing through the engine times the change in velocity.

Dr. Manildi then went on to describe several methods for testing pulse or ram-jet types of engines. The testing of ram- or pulse-jet engines in airplanes has not been too successful because of the limited maximum flight speed of the airplane and the interference effects brought

about in the airflow surrounding the exhaust section of the engine, which in some cases can effect the internal combustion of these jet engines. Three methods of statically testing pulse- or ram-jet engines in wind tunnels were discussed in which it was stated that testing in an enclosed tunnel was not satisfactory because of the high rate of heat release by this type of engine. Testing in an open type of tunnel, in which a very high speed blast of air is simply directed at the test engine and no effort is made to regain or re-use this air supply, has not been too satisfactory because of the high horsepower requirement and also the rather close proximity of walls or ground, which again could possibly affect the engine internal combustion. A brief explanation of the test setup that is approaching completion at the Giannini company was described. A series of piston engines driving blowers is used to supply air in regulated quantities to the inlet of the test engine, and a series of evacuators will be used to draw away the exhaust products to assimilate altitude conditions. This type of test apparatus is certainly the simplest and cheapest to place into operation; also, it will give the most ideal operation of the engine and would not bring in any outside effects either at the front or rear of the engine.

Mr. Kroon then introduced Robert E. Hage, Senior Group Engineer, Preliminary Design Section, Boeing Airplane Company, whose talk concerned "Jet Propulsion in Commercial Air Transportation." Mr. Hage's talk consisted of excerpts from a booklet recently published by the Princeton University Press with the same title. Aviation entered World War II with one type of power plant—namely, the internal combustion engine. However, by the termination of the conflict, four radically different types of power plants were available to the aircraft manufacturer—namely, the rocket, ram jet, turbojet and turbo-propeller power plants. From the beginning, the ultimate goal in commercial aviation has been increased speed with increased safety, reliability, and economy. A simple curve was exhibited which predicted, in 1951, jet bomber flight speeds in the order of 620 m.p.h., turbojet-powered transport flight speeds of 450 m.p.h., and commercial transports powered by turbo-propeller engines with speeds of just slightly over 400 m.p.h.

It was required that a careful analysis of variables—such as availability of engine types, fuel requirements, take-off and climb performance, block-to-block speeds, comfort, direct and indirect operating costs, profitable operating ranges, and desirable airplane size—be completed to evaluate this problem. It was stated by Mr. Hage that practically everyone in the aviation industry who has studied the problem agrees that jet-powered transports are close at hand and are much nearer an actuality than most people previously believed. As a result of the studies it appears that the turbojet engine would first be used because the greatest operating experience has been received on this type of power plant. At the present time it seems that the turbo-propeller engine is approximately 2 years in development behind the turbojet engine.

Results of the various studies in the form of curves were exhibited showing the relationship of such items as effect of cruise on cost per ton-mile, range on weight, block speeds on range, block speeds on passenger capacity, and block speeds on flight distance. The problem of airplane operating costs as compared with range was discussed, and the different characteristics that a turbojet-powered airplane exhibited as compared with the turbo-propeller-powered airplane were pointed out. After the 1,000-mile range point is reached, the cost of operating a turbo-propeller-powered airplane per ton-mile does not increase appreciably as the range is increased. However, in a turbojet-powered transport, whether of the swept or conventional wing design, operating costs per ton-mile increase noticeably as range studies are made either above or below the 1,000-mile point. Fuel breakdowns were given for the three main types of power plant—namely, the reciprocating engine, turboprop and turbojet power plants, in which, at a 1,000-mile range, 40-passenger load, runway length of 5,000 ft., required fuel loads were as follows:

Reciprocating engine.....	5,600 lbs., 300 m.p.h. cruise speed
Turboprop engine.....	10,200 lbs., 440 m.p.h. cruise speed
Turbojet engine.....	23,780 lbs., 500 m.p.h. cruise speed

In the way of breakdown of direct operating costs, the reciprocating engine power-plant fuel cost amounted to roughly 30 per cent of the total; whereas in the turboprop engine this value was approximately 27 per cent, and in the turbojet engine 50 per cent of the total operating cost was relegated to fuel.

In summarizing, it was stated that a turbojet-powered transport designed for a 1,000-mile radius could, by operating at ranges just on either side of this optimum figure, handle economically approximately 80 per cent of the commercial transport travel. The effect of block speed on this has an important relationship to size. On the basis of 300 turbojet-powered airplanes with a block speed of 450 m.p.h. with a 30-passenger capacity, 10 million passenger-miles per year could be handled. For example, approximately 1,100 DC-3's would be required to handle 10 million passenger-miles per year at 70 per cent pay load, assuming 10 hours per day utilization of the airplane. The small capacity, that is 30 passengers, for a jet-powered transport could operate with greater frequency than a larger size airplane. The effect of a high-speed, high-frequency schedule would tend to generate more business and would also permit skip-stop schedules so that every major center of population would be adequately serviced each day.

The building of a turbojet-powered transport is only delayed at the present time by the lack of sufficient funds necessary to carry on such projects. The assistance of the Government is absolutely required to help finance such a project because of the increased complexity of aircraft, in general, as well as the much higher

labor and material costs. When making a few estimates as to decreasing the airplane drag and decreasing the specific fuel consumption of the turbojet engine, its operating cost in the near future will be entirely competitive with reciprocating-engine-powered transports used today.

In the brief discussion that followed, Dr. A. L. Klein, of the California Institute of Technology, stated that one of the big problems in operating this new type of transport would be the operating procedure, both in the air and on the ground at the airport facilities. He further stated that there was a definite need to build airplanes of this type in order to work out satisfactory flight and ground handling problems.

Mr. Kroon then adjourned the session.

Afternoon Session, July 16

By

Harold B. Crockett

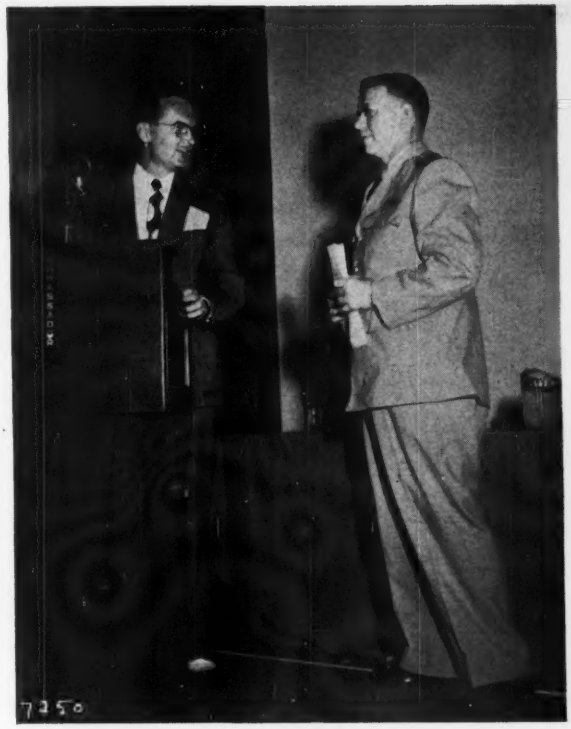
Aerodynamics Engineer Lockheed Aircraft Corporation

When Program Chairman Joseph E. Barfoot, of Douglas, introduced Capt. Walter S. Diehl U.S.N., as chairman of the afternoon session by saying, "I feel that I have known him for a long time, even though I just met him yesterday," many others of us felt just the same. There was an atmosphere of genuine appreciation to Captain Diehl for all that he has given the industry and the country in his 30 years' work with the Navy and in his present capacity as Assistant for Research Liaison, Bureau of Aeronautics.

Captain Diehl welcomed the guests and members of the Institute, and, after commenting that all discussion would be held at the end of the session, introduced the first speaker of the afternoon, H. B. Dickinson, Flight Test Supervisor, Lockheed Aircraft Corporation. The title of Mr. Dickinson's paper was "Some Results of Boundary-Layer Control Tests in Flight and in the Wind Tunnel."

Boundary Layer Control.—Many were looking forward to hearing Mr. Dickinson's paper because of the interest aroused in boundary-layer control by Dr. Sydney Goldstein, Wright Brothers Lecturer, in his recent visit to the West Coast. Undoubtedly, the question in numerous minds was: "Will Dickinson's tests bear out Goldstein's theories?"

Mr. Dickinson introduced his subject by expressing the air-frame manufacturer's point of view that a boundary-layer control system must reduce the drag for high-speed and long-range flight or the performance gains would be considered insufficient to justify the complication and developmental difficulties involved. Guided by this philosophy, it was natural that Mr. Dickinson and those working with him (O. B. Tufts, George Toumanoff and W. Hayes) thought first of developing slots and ducts that would have internal losses low enough to result in a net reduction in drag for the system.



W. R. Sears, Cornell University, and Capt. W. S. Diehl, U.S.N., Chairman of Session.

Slot-duct combinations were designed to solve the hypothetical problem for a wing of aspect ratio 10, taper 3:1, root thickness 20 per cent, and tip thickness 12 per cent. A single slot was assumed to be about 60 per cent of the chord on the upper surface only, and the airfoil was of the NACA 66 series for the purposes of establishing the wing depth available for the duct. These characteristics were selected with a large aircraft of four or more power plants in mind. It was assumed that they would be distributed more or less uniformly out the span with a blower located in each nacelle, the outer fed by the outer panel and the inner by the inner panel. Numerous wind-tunnel tests were conducted to determine the optimum shape of the slot and ducts, as well as what types of vanes were necessary to prevent separation of flow in the ducts. Upon final adjustment of the better duct-slot combinations, it was found that the flow was sufficiently smooth to permit the introduction of a light wool strand through the slot at the wing tip, around the turn through the vanes, and along the length of the duct to the blower entrance so that the wool took on the appearance of a wire bent to conform to the flow path.

Wind-tunnel tests of the wing with boundary-layer suction showed important reductions in the *thrust* required of jet power plants, but the total *power* required, including the blower, was only reduced in the wind-tunnel tests at the higher lift coefficients because of the excessive losses in the slot-duct system. Flight tests, conducted on a special two-place P-38 airplane equipped with envelopes outboard of each boom, gave substan-

A. E. Puckett, Jet Propulsion Laboratory, California Institute of Technology.

tially the same results, although the fact that the test panels were in the propeller slipstream made the results more difficult to evaluate. Mr. Dickinson concluded with the statement that, when we get wings aerodynamically clean enough to get laminar flow, we can expect results approaching those predicted by Dr. Goldstein; however, the ducting structural and weight problems are great and the development of such systems would appear to require a lengthy and meticulous experimental program.

In the discussion period, Dr. Clark Millikan, of California Institute of Technology asked Mr. Dickinson why he used slots on the upper surface of the wing only, if the primary purpose of the system was the reduction of drag. Mr. Dickinson said this was done for simplicity, that the lower surface effect would not be so great, and that in an actual case one might want to add a third boundary-layer control slot at the nose of the airfoil in order to increase the maximum lift coefficient.

Supersonic Wind Tunnel.—The second paper of the afternoon was that given by Dr. A. E. Puckett, Chief, Wind Tunnel Section, Jet Propulsion Laboratory, California Institute of Technology, entitled, "Design and Operation of a 12-In. Supersonic Wind Tunnel." Dr. Puckett opened by saying that the tunnel had just been put into operation and that the points that he intended to cover were its construction, the definition of the kind of performance expected, and what it actually will do. The tunnel, which has a variable-area test section, was designed around an existing compressor. The section dimensions are 12 by 12 in. at a Mach Number of 2.0 and 12 by 9 in. at a Mach Number of 3.0. Since the tunnel was designed with the thought in mind of testing jet models, an open circuit was used.

In order to obtain a flexible supersonic nozzle to give Mach Numbers in increments of 0.01 from a Mach Number of 1.2 to 3.0, the top and bottom of the tunnel were constructed of flexible $^1/_4$-in. steel plates supported by numerous jacks. By adjusting the nozzle shapes through use of these jacks, it is possible to change the flow patterns in the test section systematically and thus experimentally obtain the quality of flow desired. Dr. Puckett itemized the factors considered most important in evaluating flow in the tunnel as being the adequate control of the Mach Number, the maintenance of a small percentage error in static pressure, and the maintenance of a flow inclination of $^1/_{20}$ deg. or less. These factors were studied by observing the flow pattern in schlieren photographs and determining the influence of moving any jack or any set of jacks.

Dr. Puckett concluded his discussion by stating that they had only begun to experiment with the wind tunnel but they felt that it showed considerable promise.

In the discussion of Dr. Puckett's paper, the first speaker was Dr. Th. von Kármán, of California Institute of Technology, who suggested that the correction of the flow distribution by moving the jacks might be accomplished better by making mathematical calculations rather than by using experimental influence points. Dr. Puckett replied that actually a mathematical system is being developed but that the present experimental system was used for expediency. Another question that arose was that of the cost of the tunnel. In reply, Dr. Puckett answered that approximately $50,000 had been spent for the nozzle excluding engineering and approximately $50,000 for the rest of the setup. These items, of course, were exclusive of the $250,000 compressor already on hand.

Aeroelastic Properties of Swept Wings.—Dr. W. R. Sears, well known on the West Coast for his previous work at the California Institute of Technology and with Northrop and, at present, Director of Graduate School of Aeronautical Engineering at Cornell University, gave a paper entitled "Some Aeroelastic Properties of Swept Wings," which he had prepared in collaboration with S. I. Pai, of Cornell. Dr. Sears indicated that the basic aeroelastic problems were flutter and torsional divergence. The fundamental problem was the calculation of lift distribution of an elastic wing. It was shown how, using matrix notation, the problem can be set up and solved in a rather general class of situations. Dr. Sears considered particularly two swept wings having an aspect ratio of 4 and a span of 32 ft., one of which was swept back 45° and the other swept forward 45°. The curves of lift distribution presented showed clearly the tendency for a sweptback wing to unload at the tip at high speeds and for a swept-forward wing to load up at the tip at relatively low

speeds. As speed is increased, this tendency results in higher wing root torsional and bending moments for the swept-forward wing and lower moments for the sweptback wing. With the ailerons deflected the sweptback wing shows up badly, since the aileron reversal speeds are lower because of wing bending, whereas the swept-forward wing shows up better.

In concluding, Dr. Sears suggested that with sweptback wings the static longitudinal stability may be decreased several per cent and the influence of wing bending on aerodynamic load may be important in dynamic cases. For example, wing bending may couple with airplane pitching and vertical motion to produce a variant of the common short-period oscillation of airplane dynamics.

The discussion of the paper by Drs. Sears and Pai was rather lively, with questions and comments coming from all quarters of the theater. Mr. Deming, of Hughes, questioned Dr. Sears about the mode used for bending, to which the latter replied that a fundamental symmetrical wing bending mode at zero speed was assumed.

Dr. John Miles, of the University of California at Los Angeles and Northrop, commented that instead of using the matrix method one could assume a solution and calculate the exact solution by iteration methods.

George Schairer, of Boeing, commented that the term for curvature of flow was likely to be important and that items affecting downwash could result in stability changes equivalent to moving the center of gravity 20 per cent. Dr. Sears replied that he and Dr. Pai had taken into account curvature but not downwash. Their study was simplified by assuming an elastic wing on a rigid airplane with a rigid tail surface.

Dr. W. L. Howland, of Lockheed, commented on the possibility of flutter due to spanwise load distribution shift at the stall and asked Dr. Sears if he had found any difference in this quality between swept-forward and sweptback wings. Dr. Sears stated that his study did not include data on the question.

Irv Culver, of Lockheed, was interested in the mass effects of the wing in roll. To this question, Dr. Sears replied that his calculations assumed zero rate of roll.

Carrier-Based Aircraft Missions.—The final paper of the Annual Summer Meeting was to have been given by Rear Adm. T. C. Lonnquest, U.S.N.; however, his plane was delayed en route by poor weather conditions and he did not arrive to present his paper. The disappointment of those anticipating hearing him was alleviated somewhat when Captain Diehl announced that copies of the paper were available.

Admiral Lonnquest's paper is entitled "Naval Aviation and the Influence of its Mission on Carrier-Based Aircraft." Its purpose is (1) to describe the role of sea-air power in relation to the overall aspects of national defense; and (2) to summarize the influence that the mission of carrier-based aviation exerts on the design requirements for aircraft which it utilizes. Admiral Lonnquest states that in World War II air power came magnificently of age, and the record of its accomplishments all over the world are a tribute to the fighting spirit, the courage, the sacrifice, and the technical competence of those who forged and utilized and supported this most formidable agency of war. He further states that we should have no false sense of security, that behind the record of stupendous destruction established by air power emerges another aspect of great significance—the recuperative powers—the dogged will to resist and the extraordinary durability under conditions of war damage displayed by certain nations during the past war. Of particular significance is the statement by the Strategic Bombing Survey that the power of a police state over its people cannot be underestimated. The morale of the people, their belief in ultimate victory or satisfactory compromise, and their confidence in their leaders declined; but they continued to work efficiently as long as the physical means of production remained.

Admiral Lonnquest's paper then launches into a discussion of such items as continental defense, long-range air assault, antisubmarine warfare, role of carrier-based aviation, influence of the mission on carrier aircraft, and environment for the pilot.

The paper closes by quoting John Nicholas Brown, the Assistant Secretary of the Navy for Air: ". . . There is no competition between the Air Force and the air power of the Navy. They are complementary, and the functions of each do not duplicate those of the other. Together, under unified command, they provide an assortment of tools which is essential. Each has functions that now and tomorrow only it can perform. Both require your support."

Finale.—In concluding his role as chairman of the afternoon program, Captain Diehl expressed appreciation both for the speakers and for those who evidenced interest by asking questions. He then turned the session back to the program chairman, Mr. Barfoot, who adjourned the meeting.

Commander Hayward*

on

"The Military Application of Atomic Energy"

Excerpts from Address by Commander Hayward, at I.A.S. Annual Summer Meeting Luncheon, July 16.

"MOST OPINIONS about the historical meaning . . . of atomic weapons can be divided into two types. One, . . . adhered to by a number of military leaders, maintains that no essential change in warfare or in history is brought about by the introduction of atomic weapons. The great principles of military strategy stand unaltered.

"The other set of opinions . . . holds that the discovery and use of nuclear energy . . . have thrown us into an altogether new stage of history. To be in accord with the new revolutionary age of nucleonics, we must also revolutionize our ideas."

Both Views Correct

"The first view is correct in that atomic bombs . . . are made and used by human beings who do not change their traits at the moment of constructing an atomic bomb.

"Nevertheless, the second view has also its truth. The uniqueness of atomic weapons lies in the fact that for the first time since the history of the world began, man has in his hands the definite material possibility of the total annihilation of life.

"Coming to technical questions, 'Why is a nuclear age possible?' The answer is that by some accident of nature a fairly rare isotope of natural uranium breaks up or 'fishes' when the nucleus is struck by a neutron, and this fission is accompanied not only by the release of energy but also by the ejection of from one to three neutrons. Uranium 235 is the only atom available in sufficient amounts which can support a chain action. The other two atoms that can support a chain reaction are not available in nature and must be made from transmutation from other elements . . . So you see, the above facts make the widespread use of atomic energy fundamentally limited by the scarcity of nuclear fuel.

* Commander J. T. Hayward, U.S.N., Special Weapons Test Center, Sandia Base, N.M.

"The technical impact of this development, plus the German V-2, led to a strange kind of algebra in our country which was, A little Uranium 235 plus a V-2 and, presto!—push-button warfare . . . However, as you and I know, it isn't that easy, and so we come to our big problem and one with which you gentlemen are directly concerned, and that is delivery of the atomic weapon."

Methods of Delivering A-Bomb

"As a fundamental premise, all methods of delivery should be investigated completely, even to a group of men meeting in a hotel with various bits and pieces. The delivery problem can be approached either by huge aircraft, long range with relatively low speed, or by small high-speed aircraft but with short range . . . There is no one solution, and the nation better have as many arrows to its bow as possible . . . Naturally, being a Naval Aviator, I am convinced that we should be able to deliver this bomb from an aircraft carrier . . . yet I will be the first to admit that they cannot take over the strategic bombing functions of land-based air. However, time might show the best method of delivery to be from a submarine by a guided missile.

"A brief review of the delivery problem is in order. When you compare an atomic bomb with a chemical explosion, it represents a concentration of releasable energy by weight or mass factor of hundreds of thousands, which means a linear factor in the hundreds; this fact alone would constitute an adequate reason for modifying the philosophy of delivery. By philosophy, I mean the statistical success, which is all we demand in the case of projectiles, torpedoes, etc. When to this

great increase in destructive potency is added the fact that each bomb represents a distillation from a far from limitless stockpile of ore carried out by a large industrial effort, it can be asserted that the bomb is in many respects more important than its vehicle. In my opinion, the only qualification to this statement, and it is a major one, lies in the fact that the ultimate limit of reliability of any system is human. There is no way to elevate inanimate matter above brains and judgment.

"The next and last but not least military problem facing us from the 'Atomic Age' has to do with the hazard from nuclear radiation. . .

"In the case of an air burst, the actual detonation of the bomb releases a considerable amount of gamma radiation in a practically instantaneous flash. This is followed by heavy gamma radiation from the fission products in the cloud of fire, which, fortunately, rises rapidly toward the stratosphere. Thus, after a few seconds, no more radiation damage will be done by a fairly high air burst atomic bomb.

"In the case of a subsurface, particularly shallow underwater, burst, the self-cleansing action of an air burst is largely absent, with the result that there is a major permanent hazard due to the lingering radioactivity."

Training Program Paying Dividends

"As a result of the experience gained in handling the aftermath of the Bikini subsurface atomic bomb test, training and material development programs were instituted in the fall of 1946 and are now paying dividends. Provided these programs are kept in a healthy and realistic basis, there will be, throughout the Military Establishment, knowledge of the hazards of atomic warfare, including sound methods and instruments for coping with them.

"I would again emphasize that the radiological safety programs that are adequate to handle a subsurface atomic burst are much more than adequate to cope with an air burst.

". . . I have become convinced that we can make sound progress in the development of these weapons and their delivery vehicles only if we have, in addition to experts in certain essential highly specialized fields, high and intermediate ranking officers and responsible scientific and industrial advisers who have a thorough knowledge of the overall problem. Only in this way can we guard against some one group of enthusiasts taking the bit in their teeth and overemphasizing one aspect to the detriment of the whole effort."

Warns Against "Sunday Punch" Idea

"Finally, I would like to point out that there is a danger in *overemphasis* on atomic energy, particularly atomic weapons. If we become obsessed with the idea that the atomic bomb is our 'Sunday punch' and slur over development of a good solid 'weekday punch,' we may, for that reason alone, find out our 'Sunday punch' is insufficient.

"If we are to have a war in the intermediate future, we must count on use of atomic weapons by ourselves and by the enemy. In such a war, a nation that is accessible to delivery vehicles faces a prospect somewhat grimmer than the one faced by England in 1938, but not much grimmer than the one faced by Germany in 1944.

"Whether we do or do not have war, the additional research tools and stimulation of thinking resulting from the advent of atomic energy in the past decade will almost certainly lead to major advances in many fields of human knowledge."

Luncheon, July 16, Annual Summer Meeting, Los Angeles. ***Left to right:*** **S. Paul Johnston, Director, I.A.S.; Th. von Kármán, California Institute of Technology; Edward H. Heinemann, Chief Engineer, Douglas Aircraft Company, Inc. (El Segundo); Commander Hayward, Guest Speaker; Willis M. Hawkins, Chief Preliminary Design Engineer, Lockheed Aircraft Corporation, also Chairman, Los Angles Section; Smith J. De France, Director, Ames Aeronautical Laboratory, N.A.C.A.; Joseph E. Barfoot, Strength and Tests Supervisor, Douglas Aircraft Company, Inc. (El Segundo), also Chairman, Program Committee, Annual Summer Meeting; and James L. Straight, Manager, Western Region, I.A.S.**

Ultimate Performance Possibilities of Sailplanes

Résumé of Symposium

BEN SHUPACK
Aerophysics Institute, Inc.

Editor's Note—The first postwar joint meeting of the Institute of the Aeronautical Sciences and the Soaring Society of America was held at Elmira, N.Y., on July 1. The following is a résumé of the Symposium held on that date.

"Mysterious even on the brightest day
To be unveiled by duress Nature doth refuse
What she reveals not to thy intellect
Thou will not force from her with levers and with screws."

These words, translated from Goethe's *Faust*, are truly representative of the spirit behind the work of the researchers in the science of motorless flight.

Huffaker's[1] studies of soaring birds prompted the study of the mechanism of atmospheric convection. Likewise, Woodcock's[2] observation of the soaring flight of birds led to a theory describing convection over water. Nor can we ignore the contributions to the solution of problems of mechanical flight which the early workers like Langley, the Wright brothers, and Lilienthal gained from their studies of bird flight. So it was not without foundation that this Symposium returned to consideration of bird flight with the hope that some contribution could be made to the ultimate improvement in sailplane performance.

The theme of this meeting can be epitomized by borrowing a quotation from the paper by A. F. Donovan of the Cornell Aeronautical Laboratory. "What factors would be included in the design of a sailplane if a megabuck (million dollars) were available to subsidize the task?" Actually, there was to be no economic

limitation to the aerodynamic perfection that was to be sought. With such a theme, it would be expected that all modern aerodynamic theories would be called on to aid in achieving ultimate soaring performance.

In his presentation of the problem, A. Raspet, of the Aerophysics Institute, brought out as the first questions—"What is performance? What aerodynamic parameters are involved, and how are they interrelated with the distribution of the atmospheric energy which is to be extracted by the combination of sailplane, pilot, and instruments?" For many years in the history of soaring every effort was made to stay in the air. Emphasis was placed on duration of flights, and therefore a low sinking speed was sought for the sailplanes of that era. Later on, cross-country soaring began to gain in prestige over merely sitting in an up-current over a ridge. For cross-country flying a high lift to drag ratio was a principal design parameter. However, about that same time, 1928, A. M. Lippisch made two contributions which greatly stimulated distance soaring. He suggested the use of the variometer, which made thermal soaring an actuality, and he introduced the enclosed cockpit, which materially stepped up the L/D of contemporary sailplanes. With thermal soaring came the demand for high maneuverability. Here again, Lippisch contributed with the mid-wing "Sao Paulo," from which the many classes of today's sailplanes evolved. A next phase in the history of sailplane performance definition was the criterion of a flat velocity polar. Both the concept of the velocity polar and the use of it are due to Lippisch and were applied in the design of the "Sao Paulo." In recent years an additional constraint has become apparent. In thermal soaring flight the working day for a sailplanist is set by the sun. In order, therefore, to fly a greater distance, the sailplane must be able to fly rapidly between up-currents (thermals). Of two craft having the same maximum L/D, the one having the maximum L/D at a higher speed has a decided advantage when time is a limiting factor. However, high cruising speeds can be obtained only by an increased minimum sinking speed. This increase in sinking speed makes itself felt only when the up-currents are weak. It is apparent from the considerations of Raspet that a strict definition of performance is needed. An approach to such a mathematical definition is contained in Rashenbakh's paper: "Problems of Designing a Glider for Long Distance Flights." (Samolet, May and June, 1937.)

One of the guests, a noted scientist, answered Raspet's query as to the ideal size of a sailplane by a presentation of all of the controlling variables in the form of a nomograph (Fig. 1). This nomograph appears to be a powerful tool for exploring a family of designs. Inspection of Fig. 1 shows various points representing the minimum drag coefficients of a group of sailplanes that were carefully flight tested. It is seen that these craft have a drag even higher than expected of a rough surface airfoil. This is, no doubt, true because the stabilizing surfaces are not included in the total surface, the drag coefficient being based on wing area. This nomograph also answers the question of what gain is to be expected from the use of laminar-flow airfoils. It is clear that the next advance in sailplane performance will be made by some means of retaining a laminar boundary layer over at least a portion of the airfoil.

What structural elements will be required to retain the accuracy of the aerodynamic lines were mentioned by S. W. Smith, of Bell Aircraft Corporation. R. M. Stanley, formerly of Bell Aircraft Corporation, took a negative view in the ensuing discussion on the possibility of utilizing laminar sections because he felt that any small surface protuberance would initiate transition. On the other hand Raspet and Donovan, as well as T. P. Wright, of the Cornell Research Laboratories, felt that laminar sections offer great promise. It appears that now is an opportune time to make a valid test of the laminar sections on a sailplane. Raspet in the discussion mentioned that the lower Reynolds Numbers at which sailplanes fly are more tolerant of small specks in the wings than those of high-speed airplanes. He also pointed out that the sailplane suffers no acoustical disturbances, which may cause the transition to turbulent flow on powered aircraft. In reply to the suggestion that suction boundary-layer control may be a solution for low drag on sailplanes, Stanley mentioned the severe weight penalty that would be involved in the suction blower installation. The work of Regenscheit and Betz on automatic suction boundary-layer control was also mentioned. In Fig. 3 is shown the scheme of this aerodynamic device. It will be seen that not only is the parasite drag reduced, but

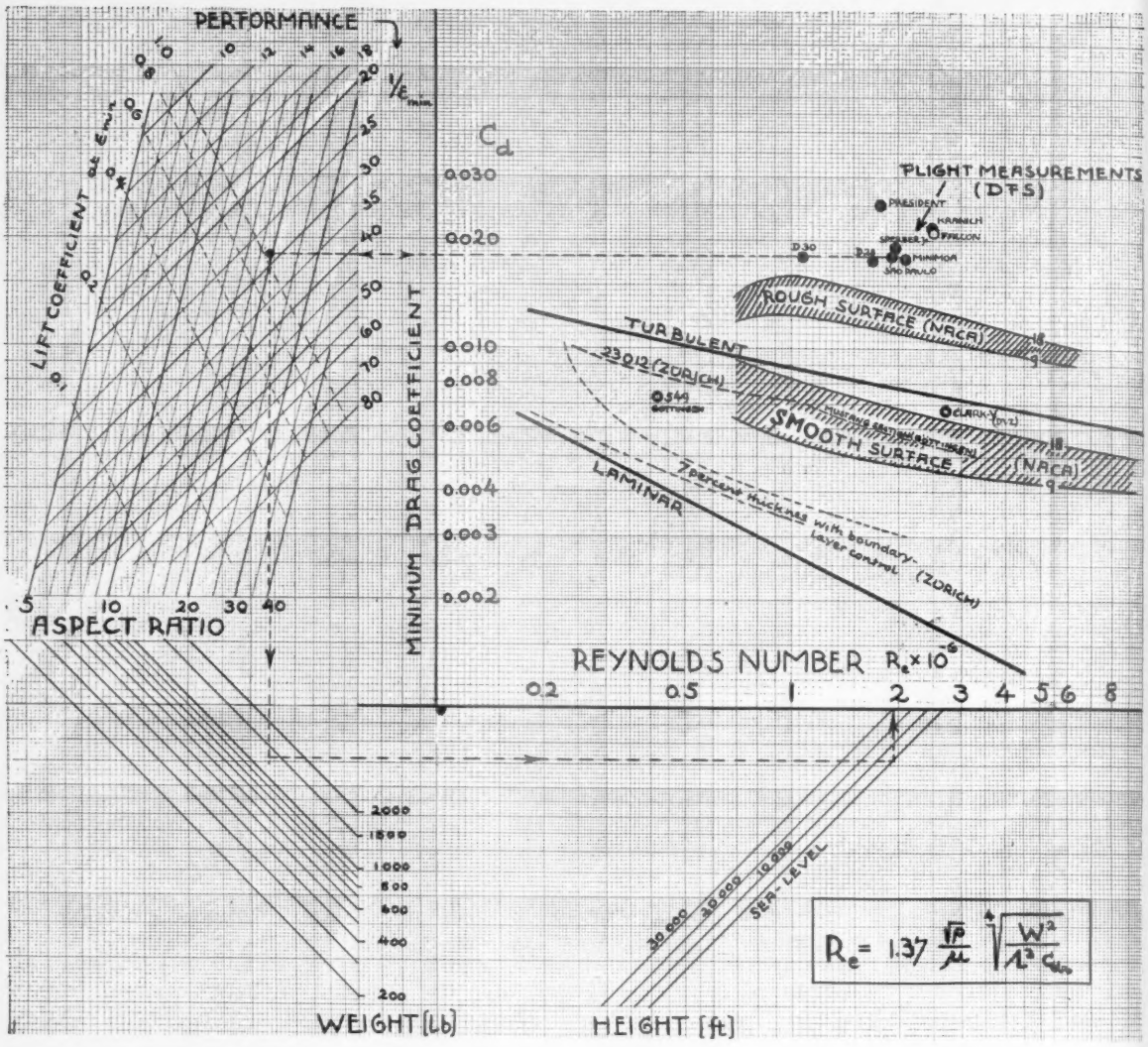


FIG. 1.

there appears an effective increase in span due to the source of flow in the wing tip. Data on this boundary-layer control system show that the induced drag would be reduced 25 per cent over an elliptic wing if the source were strong enough to place the horseshoe vortex 5 per cent beyond the wing tip.

In order to spiral at low speeds during the altitude-gaining stage of cross-country soaring, a sailplane requires not only maneuverability but also stability, and particularly it must be immune to tip stalling. Besides, the usual aerodynamic or geometric twist of the wing, slotted ailerons and swept forward wings were presented as having advantages in reduced drag over the twisted wing. Stanley in the discussion mentioned adverse control effect of swept-forward wings. It is interesting to remark here that the Russian "Stakhanovitz" two-place sailplane, having 7° forward sweep, holds all of the international two-place cross-country soaring records. Such performance is not necessarily directly tied to the swept-forward wing, but the fact remains that the swept-forward wing apparently does not possess any exceedingly adverse control effects.

Raspet appeared more enthusiastic about the Rudlicki V-tail, which Stanley pioneered for sailplanes, than Stanley himself. It should be mentioned that his "Nomad" design, using a V-tail, displayed outstanding performance.

The interference in the wing-fuselage juncture was presented as a problem of aerodynamic design, of experimental analysis, and of systematic modification to achieve a low interference juncture. The AERONAUTICAL ENGINEERING REVIEW (July, 1948) carried a series of tuft photographs on a full-scale flight test of the sailplane "Reiher." This work is an excellent example of the experimental analysis of the wing-root flow.

One visiting scientist, an outstanding researcher in the field of tailless aircraft, was not sympathetic to the tailless sailplane, feeling that the sailplane in soaring must fly at high lift coefficient. He stated that the

tailless is not a high lift design. That may explain why the tailless designs of the Horten brothers were of extremely low wing loading.

A rapprochement in sailplane aerodynamics appears in progress in the trend toward less emphasis on high aspect ratios. The extreme aspect ratio, 33, of the D-30 Currus shows such a small speed range (sharp maximum in the L/D vs. airspeed curve) that the variation of air speed required to cross downdrafts causes a severe loss in L/D. A series of velocity polars for a sailplane having a fixed maximum L/D but of different aspect ratios is shown in Fig. 2. The advantages of the low aspect ratio for speed range are apparent from the flatness of the polar. What is clearly demonstrated by these curves is the necessity of reducing the drag of the ultimate performance sailplane. By using lower aspect ratios and striving for a low drag not only is speed range improved but cruising speeds are increased.

In discussing the aerodynamics of birds, W. B. Klemperer, of Douglas Aircraft, pointed out that not all soaring birds have a low aspect ratio. In fact, he mentioned that the albatross, having an aspect ratio of 12, did not appear to follow the low aspect ratio trend of continental soaring birds as pointed out. The albatross and the land soaring birds, of course, differ as to the sources of the sustaining energy. Land soarers are thermal soarers, whereas, according to Ludwig Prandtl, the albatross soars dynamically, extracting energy from wind velocity fluctuations.

The question of the structure to be used in this vision of the "ultimate sailplane" was discussed by S. W. Smith, Bell Aircraft Corporation, in his paper: "Structural Problems." Smith began by stating that, if the plea for lower aspect ratios was heeded, the problem of designing a wing stiff enough to retail the airfoil section under varying flight loads was greatly simplified. The present high aspect ratio wings are almost impossible to build unless the wing is thick enough to contain the structure essential to the wing if it is to remain an

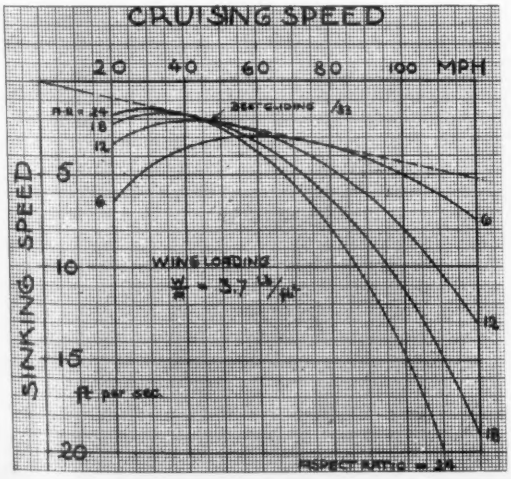


FIG. 2.

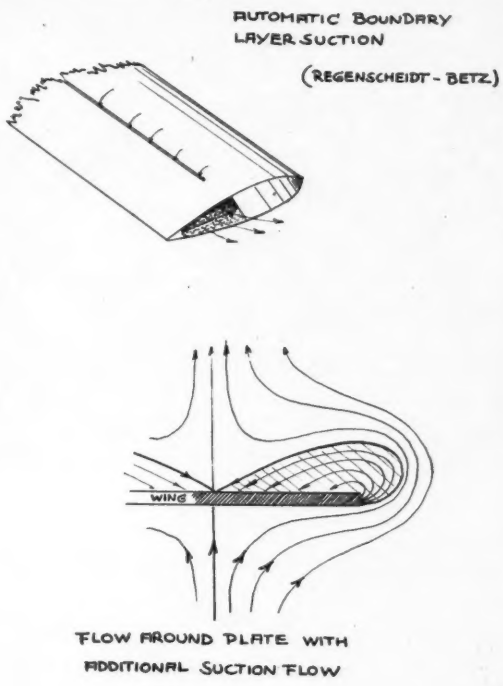


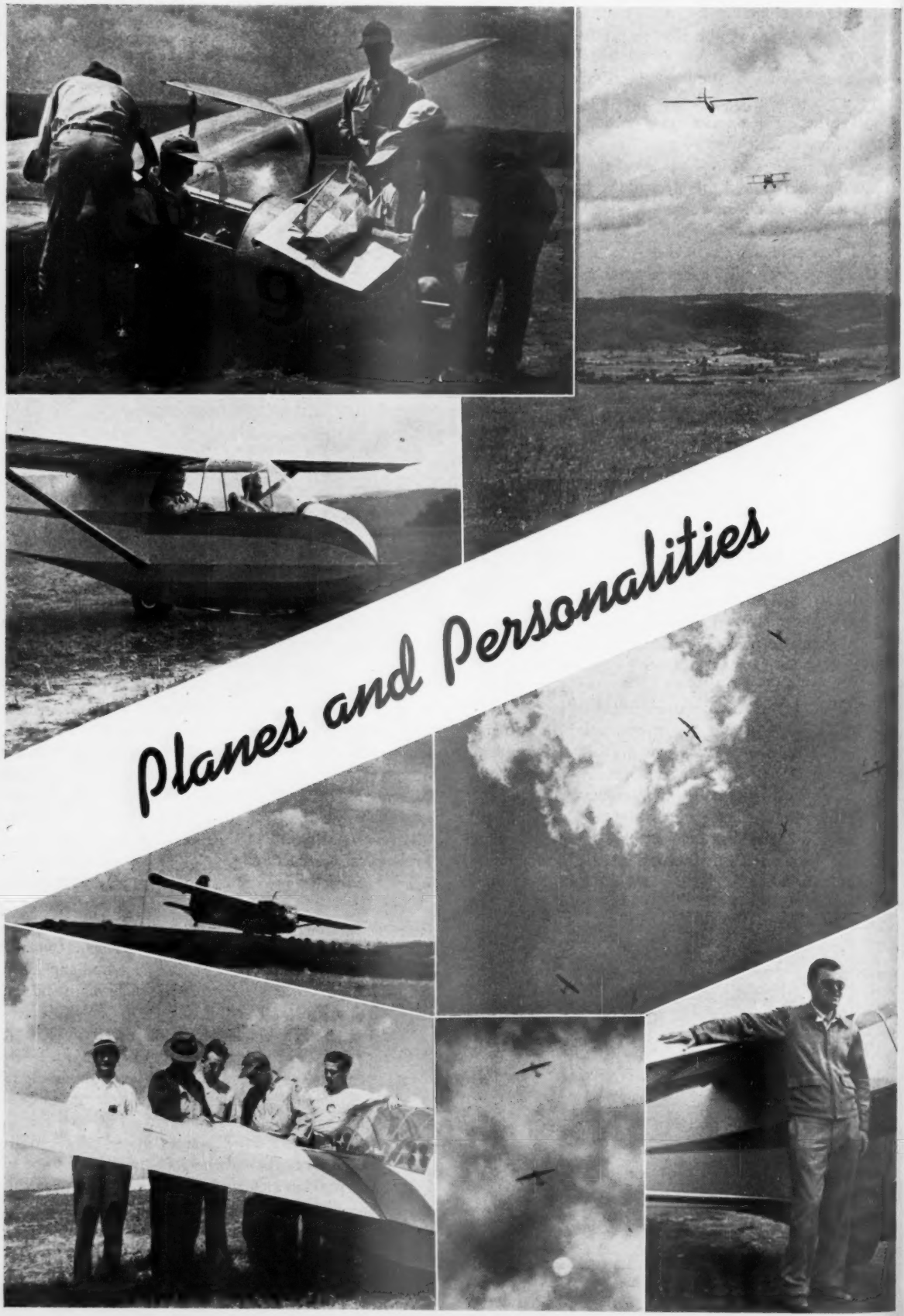
FIG. 3.

entity in flight. Such a wing cannot be built in one piece if the normal problems of transportation are considered. The present practice of two panels with the heavy root fittings might be modified by the three panel wing and consequent light wing fittings.

The suggested low aspect ratio wing of about 1:6, lends itself to the possibility of using the thin, laminar airfoil sections and still build a wing strong enough to withstand the flight loads. The intriguing possibility is presented of building one-piece wings capable of transportation. The stiffness and smoothness of a low aspect laminar-flow wing might best be achieved by using sandwich construction, going so far as to completely fill the space between the upper and lower wing surfaces with some low-density, low-weight material to make the wing one big sandwich. Smith touched briefly upon the problem of the fuselage and expressed the opinion that the pod type of fuselage might be the best for this "ultimate sailplane."

The "Design Problems" were discussed by Ernest Schweizer, of Schweizer Aircraft Corporation. His views were that of a practical engineer designing a practical sailplane, possible of production under conditions that would make the ownership of such a sailplane a possibility for the average glider pilot. With this in mind, he cautioned the panel of speakers not to ignore the problems of tooling, jigging, materials, and man-hours of labor the "ultimate sailplane" would require.

Robert C. Kidder, Cornell Aeronautical Laboratory, followed with this paper: "Performance Calculations and Flight Test." In his discussion he reviewed briefly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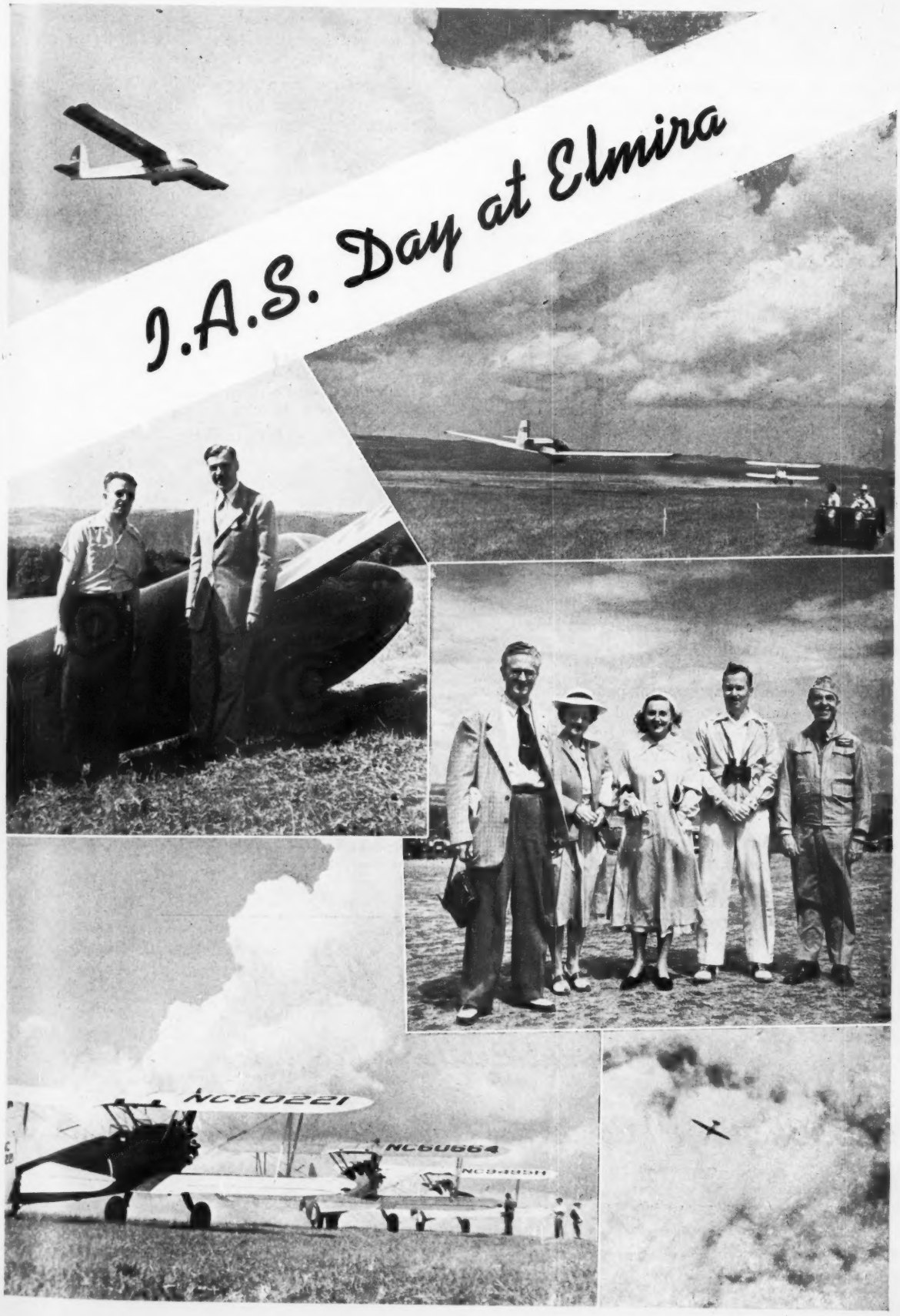
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the wind-tunnel procedure of collecting data upon which to base the assumptions guiding performance calculations. Kidder stated that the finished glider is a compromise of the parameters presented by the previous speakers. In discussing the instrumentation of the sailplane for precise flight testing, Kidder described the errors likely to occur, notably the position error of the pitot-static tube. He strongly urged that a performance curve be standard equipment in each glider and that glider pilots learn to fly according to the performance curve. In fact, Capt. R. S. Barnaby, U.S.N. (Ret.), Franklin Institute, who was chairman of the Symposium, recommended the use of the gliding diagram described in this book *Gliders and Gliding*, 1930.

When A. F. Donovan, Cornell Aeronautical Laboratory, arose to summarize the talks of the speakers at this session, he remarked that before this "ultimate sailplane" could be flown there might be a need for pilot training to utilize this super performance. Donovan then went on to say that he would like to coin a new word "megabucks" to fit the million-dollar ideas presented in this vision of an ultimate performance sailplane.

It may be interesting finally to compare the conclusions reached by a similar meeting[3] held in Hamburg in 1936. At that time H. Jacobs placed emphasis on weight reduction, thin wings, small frontal area, smooth surfaces, flaps to increase lift, and jettisonable ballast.

In this symposium at Elmira in July, 1948, the emphasis for cross-country soaring performance was on the laminar shape of the wing and on striving for a laminar boundary layer. The trend appeared also to aim toward reduced aspect ratios. From the symposium it is perfectly clear that a maximum L/D of 40 to 60 is possible. Donovan's calculated performance demonstrates what is in store for future sailplane designers. The Symposium was, indeed, inspiring in that it showed the desirability of an analytic approach to sailplane design and also in that the present sailplane still leaves a large gap to be closed before the theoretical gains are achieved.

This résumé can be concluded with the following statement: "The glider, as a large-scale model, can do a lot of valuable testing in the field of low-speed aerodynamics. It will be many generations before a 'Supersonic Glider Contest' is held, but some old-fashioned aviators will always fly in the subsonic region. There are many problems in subsonic flow which can be solved by means of the sailplane." The solution to subsonic flow problems thus benefits both the pure aerodynamicist and the ultimate sailplane designer.

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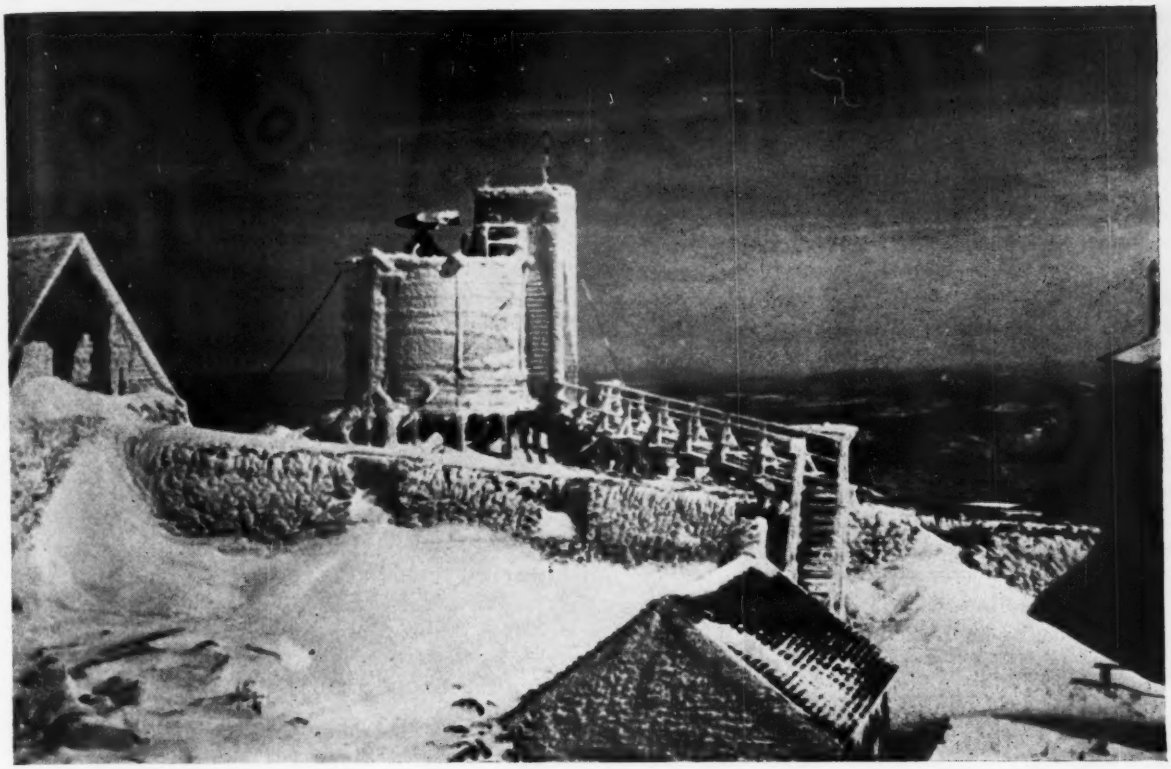

A Study of Wing De-Icer Performance on Mount Washington

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The B. F. Goodrich Company

Introduction

THE INFLATABLE De-Icer has until recently been the only device used commercially to keep airplane wings free of ice. During the past 17 years it has undergone continuous improvement in many respects, such as ease of application, resistance to aging, reduced production of static electricity (and its effect on radio reception), and reduced aerodynamic drag. Of course, the most important single property of the De-Icer is its ability to remove ice. Although there have also been improvements in this respect, it is recognized that our ultimate goal of making it possible to dispatch aircraft into known heavy icing conditions has not been met. The application of recent fundamental studies of the mechanism of ice removal in the laboratory has led to outstanding advances in the basic design. These, aided by the tenfold reduction in ice adhesion achieved by the use of silicone coatings, result in an exceptionally dependable De-Icer.

The mechanical De-Icer operates by stressing the rubber in such a way as to produce strains in the rubber-ice interface which cannot be followed by the ice. Perfect removal results if the strain in the rubber can be produced uniformly over the entire surface. This is not easily achieved, since the decay of strain at points removed from the position at which the stress is applied is rapid and nonuniform. For best results the strain must be produced near the position at which the ice is to be cleared. This is particularly true when the ice is weak or discontinuous (as in rime). Under these circumstances the small ice pieces can more easily distort

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the rubber and, consequently, decrease the stress at the bond.

A stress analysis[1] indicates that the pneumatic forces can be much better utilized by employing De-Icers composed of small-diameter tubes and cemented to the entire area to be protected. The laboratory evidence concerning the advantages of silicone treatments for reducing the adhesion of ice to the surface has already been discussed.[2] Since the De-Icer is inherently one for emergency conditions, laboratory-proved concepts must be given conclusive preflight tests before an aircraft is entrusted to its protection. Aside from the danger of flight testing any form of anti-icing apparatus, the process is expensive and the opportunity for careful observation is limited. On the other hand, even the newest refrigerated wind tunnels offer many complications concerning duplication of natural icing conditions. For mechanical De-Icers it is imperative that natural ice be duplicated exactly for, as explained above, the physical properties of the ice are also important in determining deicing efficiency.

A survey of the world's "bad spots" indicated, and 3 years of actual testing have borne out the feeling, that the summit of Mount Washington offers the best opportunity to make advanced preflight evaluation of experimental De-Icers. Further, it furnishes a suitable laboratory in which theories of ice formation and removal can be checked accurately.

Mount Washington

The meteorological factors associated with this mountain have been well described previously.[3–6] Since this information is not readily available typical weather for this station is indicated in Table 1. There it may be seen that ice is encountered on over 48 per cent of all the days of a typical year. From November through April, 86 per cent of the days have rime formations. The ice storms are almost invariably accompanied by winds of over 50 m.p.h. and winds above 100 m.p.h. are not uncommon. The mean duration of an icing storm is 14 hours. "During the year 1933 fog was recorded 318 days or 87 per cent of all days and on 2,600 or 52.5 per cent of all hours."[4] This is to be contrasted with 1,413 reports of icing out of 14,843 pilot reports by pilots flying in the Alaskan-Aleutian area[7] or the 49 flights made by the N.A.C.A. icing research ship during the winter of 1946.[13]

The abnormal weather conditions here attracted the attention of early observers.[8, 9] It was used as a weather station as early as 1870, and the present observatory* has maintained complete continuous records since 1932.[6] This group of scientists has specialized in the study of the meteorological conditions associated with icing and the properties of natural occurring ice.

The determination of the meteorological conditions associated with icing follows the rotating cylinder method initiated by Arenberg,[10] studied theoretically by Langmuir,[11] and developed extensively by the Mount Washington observers.[12] The three hourly observations of wind velocity, temperature, drop diameter,

* The Mount Washington Observatory Corporation is a privately owned nonprofit organization. At present they maintain, with the United States Weather Bureau, an active modern observatory at the summit. Through this organization other groups have carried out cold-weather projects. This report concerns the earliest dealing with ice removal. Any success we may have had is due in large part to the unselfish personal effort given by these men unhampered by organizational procedure.

Table 1
Mount Washington Weather
Computed from Data (1933–1943) as Given in Reference 5

Month	Number of Days on Which to Expect				
	Fog	Ice	T, 0°F.	Wind above 50 m.p.h.	Wind above 100 m.p.h.
January	25	24	18	28	8
February	24	24	17	25	7
March	27	26	11	28	5
April	22	20	5	23	3
May	21	10	0	21	1
June	22	2	0	17	1
July	27	1	0	11	1
August	23	2	0	11	1
September	25	7	0	18	1
October	25	14	1	22	1
November	28	24	5	26	2
December	25	24	14	28	7

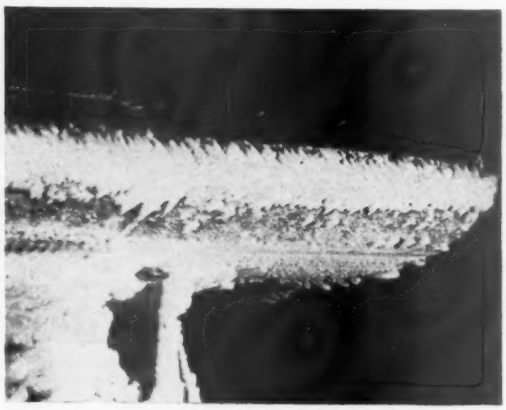

Fig. 1. A typical hard rime on half of the pivoted wing. Ice on the wing support and wire is clearly seen.

Fig. 2. The wing. A production model De-Icer on the right and one arrangement of small tubes on the left. Both are shown fully inflated to illustrate the tube configuration. Note the steel base designed to resist a 250 m.p.h. wind with flat plate leading edge.

liquid water content, and ice density which are made have been useful in analysis of De-Icer operations.

In general, our experience indicates that the mountain provides a good location for such tests. The kind and distribution of ice agree well with that obtained in flight (Fig. 1). At the time this work was started little comparable flight data were available, but just recently tests sponsored by N.A.C.A.[13] and the Army Air Forces[14, 15] indicate that the drop diameter and liquid water content of clouds encountered in flight agree closely with the conditions encountered on Mount Washington. The principal handicap in working there is the relatively low wind velocity which affects the kind and distribution of the ice. Since during a year's testing all types of ice are formed, this is not serious provided the experimenter recognizes that the preponderance of low-density ice is not typical of flight. Fortunately, the low-density ice serves as a severe test for De-Icers.

Even though the road up the mountain is open during the summer, construction work is difficult because of high winds and dense fogs. It is necessary to make all preparations and have all the construction work done and the heavy test equipment on hand by late summer before the road is closed. Testing is done under considerable physical hardships and with extreme slowness compared to valley operation.

Equipment

The experiments included three phases (1) the determination of the properties of the collected ice, (2) a study of the effectiveness of surface treatments, (3) an examination of the effect of changing methods of stress production.

The De-Icers were exposed on nearly full-scale wings in such a manner as to allow direct observation of their operation during icing and to afford a simplified means of interchanging test surfaces. Facilities were provided for supplying a wide range of air pressures at variable cycle rates. In all other regards the operation was essentially that used in flight.

The wing (Fig. 2) which has a 6-ft. span and a 5-ft. chord with a detachable NACA 0025 leading edge, is mounted 4 ft. above the floor slightly forward of the center of the 15-ft. diameter water tower (for Fig. 3 see photograph used as lead-off) of the Mount Washington Railway Company. The location, at the geographical summit, is about 100 yards from the observatory building and sufficiently high to be reasonably free of blowing snow and excessive turbulence. The exposure to the prevailing wind is unobstructed by other buildings. Vertical fins at the trailing edge maintain the pivoted wing into the wind at all times. A screw for altering the angle of attack was provided. The test section was brilliantly illuminated from all sides by fixed photofloods for observations at night. The enclosed ladderway on the lee side of the tank forms an observer's room by extending above the tower roof. This space houses an air compressor, all the various electrical and pneumatic controls, as well as the miscellaneous tools required. The ladderway is reached from the observatory by a ramp over the connecting passage between two sections of the summer hotel.

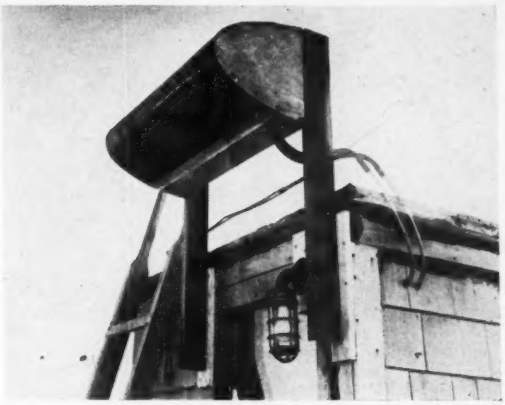

Fig. 4. The fixed wing.

The air compressor was operated by electricity furnished by Diesel generators of the nearby Yankee Network relay station. The flow of air, stored at 150 lbs. per sq.in. in a large ballast tank, to the wing was controlled by magnetic valves located in the wing and by an adjustable rate timer in the observer's room.

The test installation included, in addition to the pivoted wing at the center of the platform, a wing fixed in the direction of the prevailing wind on which aging tests were conducted, a small-scale wing to estimate scale factors, a device to measure the tensile strength of

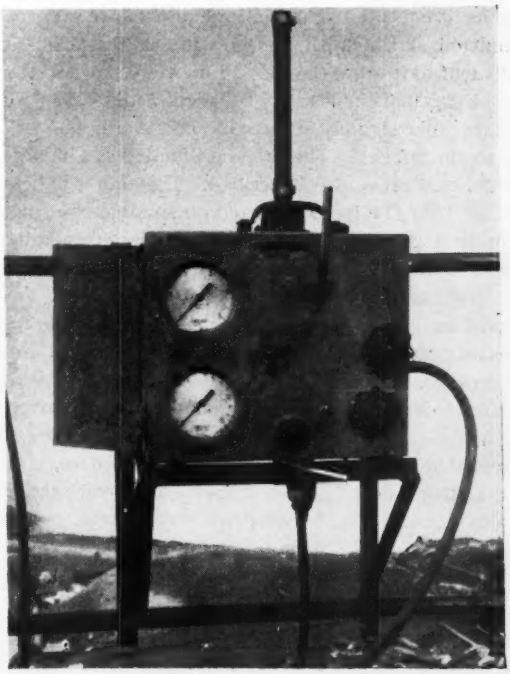

Fig. 5. The device for testing the tensile strength of ice. The vertical cylinder is the inflatable collector supplied by compressed air from a ballast tank within the box. The air pressure is read on one of the two gages.

FIG. 6. One form of ice collector for samples for measuring the adhesion of ice to rubber.

ice, and another to determine the adhesion of ice to rubber (Fig. 4, 5, and 6).

The strength of the collected ice is not a physically well-defined quantity, as can be seen by an analysis made with one particular type of testing device (Fig. 5). It consists of a cylindrical tube of rubber upon which the ice is collected. At the time of the test some air is admitted slowly until the pressure in the cylinder is sufficient to rupture the ice. From well-known formulas the strength of the ice may be calculated.

The other significant variable is the adhesion of the ice to the rubber. The method adopted is a modification of that previously described. The plan is indicated in Fig. 10. The ice is collected on small sleeves over a cylindrical shaft, cut to length and inserted radially in the centrifuge. The centrifuge is turned at steadily increasing angular velocity until the ice flies free. With almost no exceptions the ice was strong enough to resist breaking until the stress was high enough to break cleanly the ice-rubber bond. The weight was calculated from the weather data (a method that proved to be too inaccurate), and the angular velocity of the wheel at failure was determined by a magneto. With temperature, density, and mass of ice collected varying with each test, satisfactory results were not obtained.

TESTING PROCEDURE

Observations of the nature of the ice formed, its type and location on the surface, were made before the De-Icers were switched on. During operation the observer noted the rate of removal, the extent of removal, and the location of the residual ice. Since, in general, two De-Icers were mounted side by side on the wing with the outboard and inboard half of each being different in surface treatment, four different surfaces of about 1-ft. span were tested simultaneously. The observations were recorded as nearly quantitatively as possible, usually after one cycle of operation.

For completeness in comparing results the De-Icers were rated on the basis of the area entirely freed of ice rather than on the thickness of the ice removed. If by operation of the De-Icer the thickness of the ice was merely reduced, that operation was rated as zero. Operation was usually begun when the ice was less than $^1/_4$-in. thick. This choice was not dictated by recommended operational procedure for aircraft but by the desire to secure as great a differential between test surfaces as possible without getting false comparisons.

Photographs were taken freely and compared with recorded observations.* Here care is required. A white object is being pictured against a generally white background in a fog sufficiently thick to make it difficult to identify objects 6 ft. away. The camera man is subjected to wind forces that are high and variable. It is unsafe to rate the performance on the basis of photographs alone, but in conjunction with the data sheets they are extremely valuable. In analysis, an accumulative distribution curve is drawn showing the percentage of cases for which the De-Icer was given a rating of a particular value or higher.

Where possible, simultaneous measurements of the adhesion of ice to the Neoprene surface and the tensile strength of ice were taken.

RESULTS

After three seasons of testing it seems certain that tests made on Mount Washington are satisfactory. None of the results conflict with flight observations, and many observations could not have been made in any other way.

Ice Formation

The amount and type of ice collected on any particular object depends on liquid water content, wind velocity, drop diameter, and the shape of the object.[11] The amount of ice accreted by the test wing was slow, amounting to something like $^1/_2$ in. per hour. Though it is possible to calculate the instantaneous rate of ice collection, the collection over a finite time depends on the roughness of the ice deposit. Small projections in rough ice soon become the collectors rather than the wings (Fig. 7).

The performance of the mechanical De-Icer depends on the strength of the deposit as well as on the adhesion. The former depends on the thickness of the ice as well as on the density. There is a close relation between

* We have approximately a thousand pictures of wings in ice. The pictures to be reproduced represent particular features and are not necessarily typical of the collection. Only a study of all can reveal the correctness of the distribution curves shown in Fig. 15.

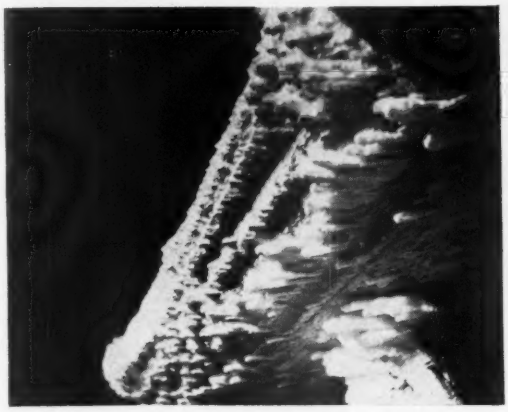

FIG. 7. Ice formed on small roughnesses. Here the tube edges of the De-Icer were sufficiently above the surface to start collections. This is an unusually striking manifestation of a common occurrence in light icing.

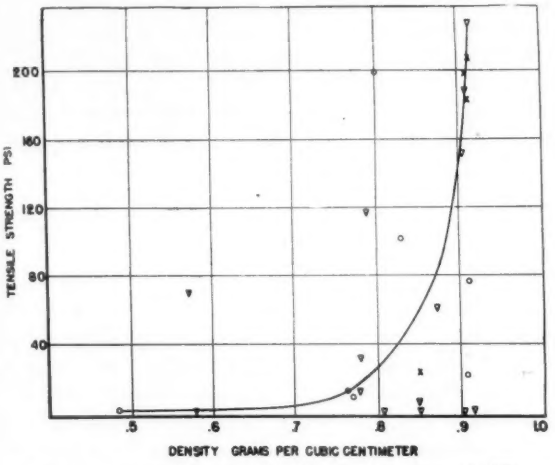

FIG. 8. The tensile strength of ice for collectors of different diameter (o for 1-in. diameter, x for 3-in. diameter, ∇ for 6-in. diameter cylinders). The density is the density of ice collected on a small collector (0.064 in. diameter). In the laboratory glaze ice has a tensile of from 110–150 lbs. per sq.in.

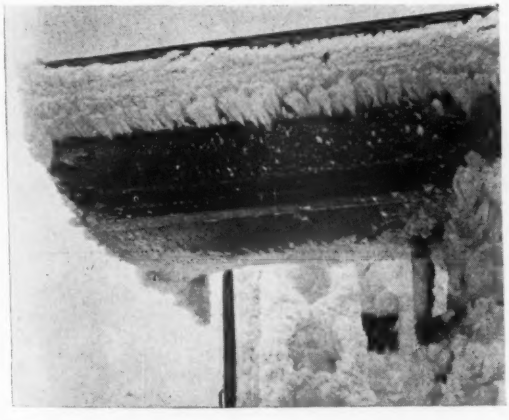

FIG. 9. The isolated feathers are typical of a rime of low density. The small area attachment can clearly be seen in the feathers on the lower edge of the formation.

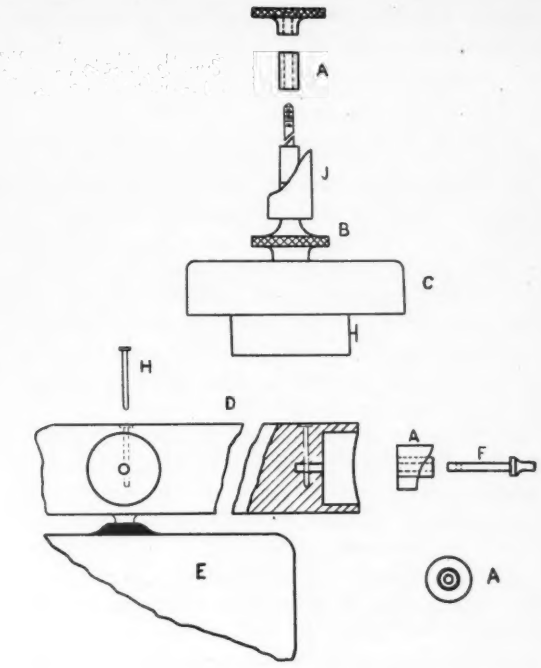

FIG. 10. A schematic drawing, exploded, of the collector and centrifuge for testing the adhesion of ice to rubber. Ice (*J*) is collected on rubber sleeves (*A*) mounted on a shaft (*B*) affixed to a slow-speed motor (*C*). After the six sleeves are cut apart, they are fastened to the centrifuge wheel (*D*) by a pin (*F*) and a securing pin (*H*). The wheel is spun to high velocity by a motor (*E*). The entire process is carried out at ambient temperature.

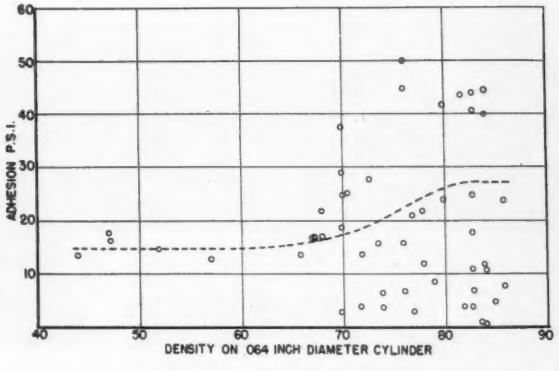

FIG. 11. The variation of adhesion with density. The collection cylinder is 0.238 in. in diameter. The scatter obscures the effect of temperature.

collection efficiency and density. In fact, preliminary calculations indicate that an empirical equation can be written which relates these two quantities.

$$1.89\rho = \log_{10}E - 0.26$$

ρ = density, Gm. per cu.cm.
E = collection efficiency, per cent

The ice density appears to depend on the fraction of the drops caught by the collector rather than on the temperature, wind velocity, or drop size per se. This fraction is a joint function of drop size, wind velocity, and collector diameter. Low collection efficiency is usually associated with low temperature, but it should be understood that it is not the temperature that controls the ice type. Low-density ice may form at high temperature or glaze at low.

The tensile strength as measured is shown in Fig. 8. The great scatter of the data arises because the coat is frequently not continuous (Fig. 9) or is extremely variable in thickness. A more desirable test would measure the strength of the isolated feathers.

Fig. 11 illustrates the variation of adhesion with density. The relation between tensile strength and adhesion is well shown by photographs of De-Icers partially freed of glaze and those partially freed of rime. The glaze comes off in ribbons and rime comes off in spots (Fig. 12). In every case glaze can be more easily removed than rime.

Many authors have stated careful and extensive definitions of ice types. These have value in aiding rapid descriptive work but are confusing when they imply that the types are distinct. It would be preferable to describe the ice in terms of density and roughness.[16] For our purposes it was convenient to identify the ice type according to the ice adjacent to the wing. Occasionally, rough glaze formed first and rime formed on the glaze roughnesses. From the point of view of ice removal, the glaze undercoat is more significant than the rime that is apparent on the surface. Often the differential rate of ice accumulation in rime ice produces feathers that build up over others forming more slowly. These latter are not removed when the cap is dislodged. When glaze ice forms it is always dry. If water is present, it is on the surface or between the ice and the wing. Slush was never observed.

Low-density ice occurs on Mount Washington more frequently than would be encountered in flight, because the velocity with which the drop strikes the wing is lower. Attempts to circumvent this disadvantage by the use of small model wings cannot be successful, since a number of dimensionless variables are involved Nevertheless, trials do indicate that a small wing collects a smaller, more dense cap that can be removed more easily by mechanical means. Thus the performance figures for De-Icers on the mountain are a conservative representation of their performance in flight.

Treatments applied to De-Icer surfaces for the purpose of reducing adhesion do occasionally affect the amount of ice deposited. Observations from a position near the wing surface have indicated that this occurs when the ice forms in nodules. If the nodules are high enough to present enough surface, drag forces will overcome adhesion and the ice will be torn off (Fig. 13). It is doubtful whether the pneumatic forces ever completely remove the ice from a wing without the aid of drag forces.

De-Icers

Controls

The De-Icers used for control or reference purposes were full-scale production models of only 3-ft. span. The two types used had tube configurations indicated in Fig. 14. Because of the large diameter these tubes inflate fully under 8 lbs. per sq.in. pressure.

The performance of most of the major classification of boots tested is shown in Fig. 15. These curves represent the most extensive De-Icer evaluation yet pre-

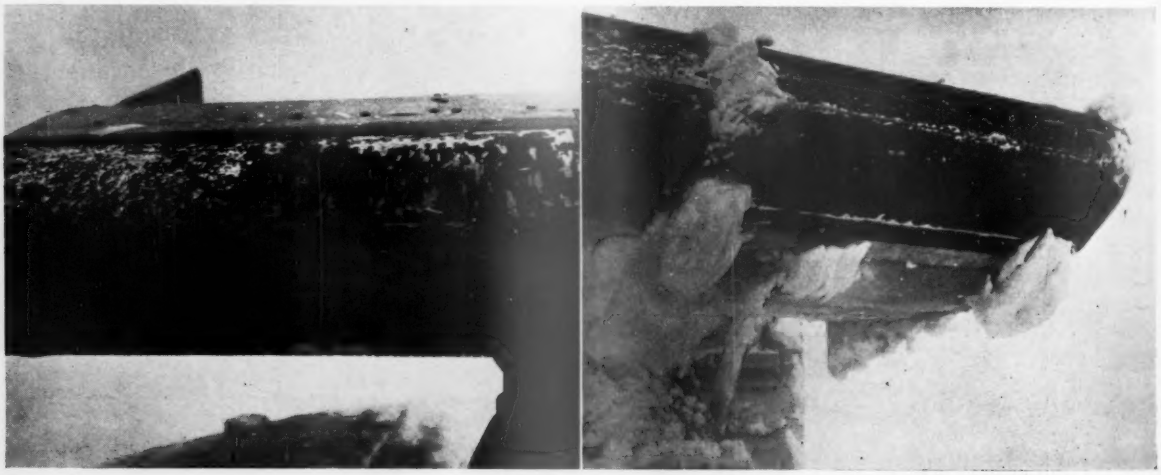

FIG. 12. Residual ice. When glaze is freed, all or none of it is removed. When rime is acted on, the thickness of the layer may be just descreased. Failure occurs within the ice. The glaze in the photograph is white, indicating that it is free of the wing and can be blown off. Rime is frequently left along the tube edges where action is slight. Big deposits of ice on this and other pictures are formed on the wing where no deicing protection is afforded.

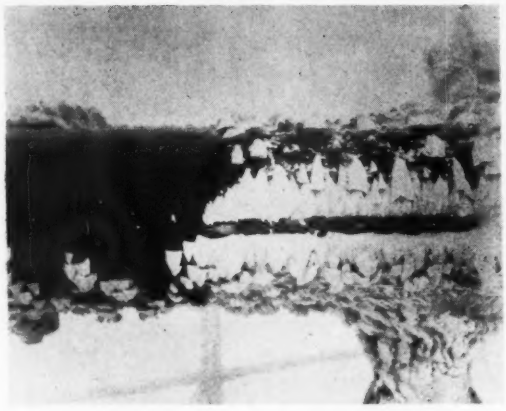

FIG. 13. The left end of the wing had been treated with silicone elastomer just prior to this run. The De-Icer had not been operated. The ice formation on the untreated section indicates the type of ice forming. No ice on the stagnation line is common.

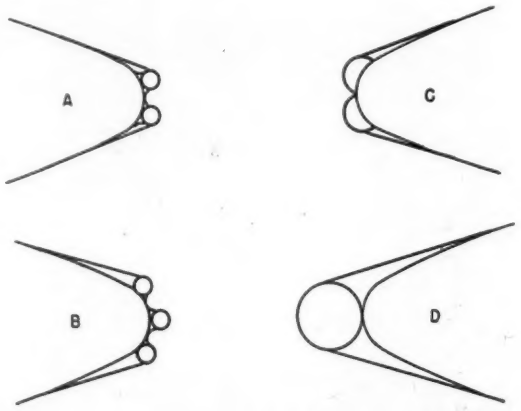

FIG. 14. The tube configuration of the two production model De-Icers used. A and B are alternate tube inflations of Type 11, and C and D are alternate inflations for the Type 12.

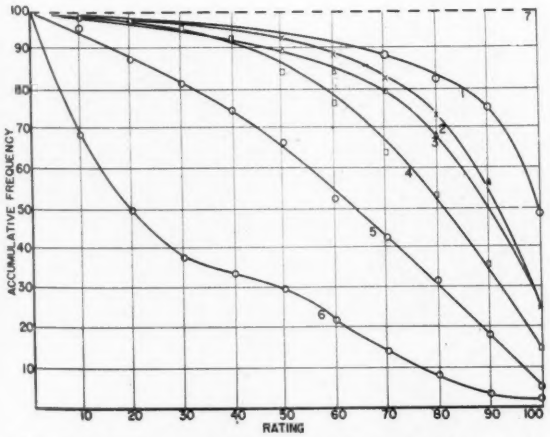

FIG. 15. Performance of the various De-Icers tested. Curve 6: Type 11 stretch area 1944–1945; Curve 5: Type 11, tube area 1944–1945; Curve 4: Type 12 tube area 1945–1946; Curve 3: tube area treated 1945–1946; Curve 2: small tubes (0.5 in. diameter) 1945–1946; Curve 1: small tubes (0.5 in.) treated; Curve 7: perfect performance.

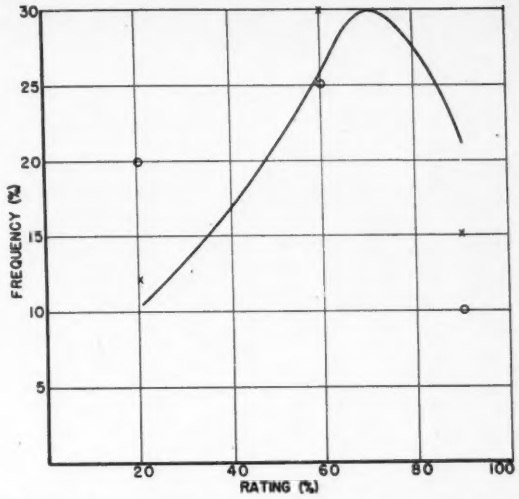

FIG. 16. Comparison between flight and Mount Washington tests. The solid curve represents the data for the Type 11 De-Icer accumulated on the mountain. The American Airlines data are shown for DC-3 (o) and X-C-54A (x). The latter data were recorded by the pilots as "little," "most," and "all" of the ice removed and were given the arbitrary rating of 20 per cent removed, 60 per cent removed, or 90 per cent removed for the purposes of comparison.

sented. Each curve is computed from over 200 individual observations by different observers and includes all types and amounts of ice. Assuming constant rating techniques, one finds that Type 12 removes ice from the tube area more efficiently than does Type 11. Both fail to clear the wing of ice in too large a fraction of cases. The stretch area is particularly ineffective. This is not an entirely fair observation because the ice forms more slowly there. When operations are begun with thin leading edge ice, that on the stretch area is extremely thin.

These results are more extensive than any others that have been reported. An extensive check of pilot experience of American Airlines during the winter of 1944–1945 is in reasonable agreement with our results.[17] In Fig. 16 an attempt has been made to compare these flight tests with those measured on the mountain. Some adjustment of the size of unit cells is required, since the pilots merely reported whether "all of the ice," "most of the ice," or "little of the ice" was removed. The agreement is as good as could be expected.

Though Fig. 15 indicates mediocre performance for standard De-Icers, it should be remembered that our testing procedure and methods of rating were drastic. Since these are De-Icers of the type that have performed well in service, they represent a definitely successful, practical removal of ice. However, on an ideal or on a scientific basis they leave much to be desired.

Silicone Treatments

It seems to be generally expected that better performance could be obtained if the adhesion of ice to the surface could be reduced. Many methods for reducing this adhesion have been developed, but all have had the disadvantage of short life. The best of these seem to be

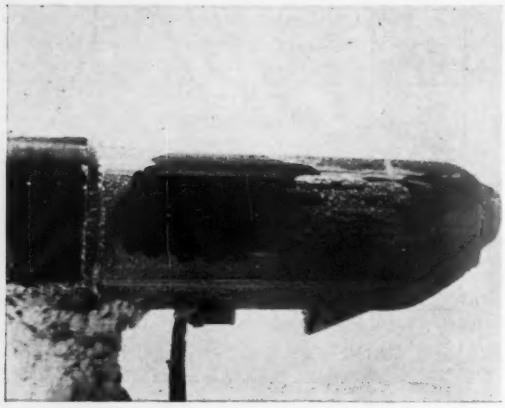

FIG. 17. A production De-Icer. The inboard end had been treated 3 days prior to this test. The photograph clearly illustrates a rough glaze.

the high viscosity silicone oils or elastomers.[2] The laboratory results are substantiated by a study of treated De-Icer performance. Curve 3 of Fig. 15 shows conclusively that the treated surface is superior; in 69 per cent of the cases the rating was 80 or better as compared with 54 per cent for the control. A like improvement is shown by curve 1 for the small tube De-Icer to be discussed below. Some typical differences are shown in the photographs of Fig. 17. The data were compiled over a period of a month or more. Since the effectiveness of the treatments decrease with age, it is obvious that tests on fresher treatments would show even greater differences.

Similar improvement has been found in a few flight tests performed by American Airlines and by United Air Lines.[18] No pictures are available and no extended observations were made, but in the few tests performed there was no question about the superiority of the treated surfaces.

The vigorous abrasion to which an aircraft surface is subjected in flight makes the question of durability of any surface of extreme importance. Mountain conditions are not well suited for this type of evaluation, since too many of the variables involved cannot be controlled. The extensive observations required for statistical analysis are impractical.

The best evidence indicates that a treatment using the Dow Corning Silicone elastomer will reduce the adhesion significantly during 6 weeks of service on the mountain. Flight tests to determine a comparative evaluation were inadequate. When these results are correlated with the rate of decrease of effectiveness on the surface being eroded by high-velocity water spray in the laboratory it is concluded that a successful treatment must reduce the adhesion below 14 lbs. per sq.in. as measured on the centrifugal device. In light of this, the graph, Fig. 18, of the adhesion of the silicone elastomer treated surface as a function of time of exposure to Mount Washington summer weather is instructive. On this basis the treatment is completely satisfactory for 3 weeks, reaches a constant value in about 6 weeks, and always remains better than the untreated surface.

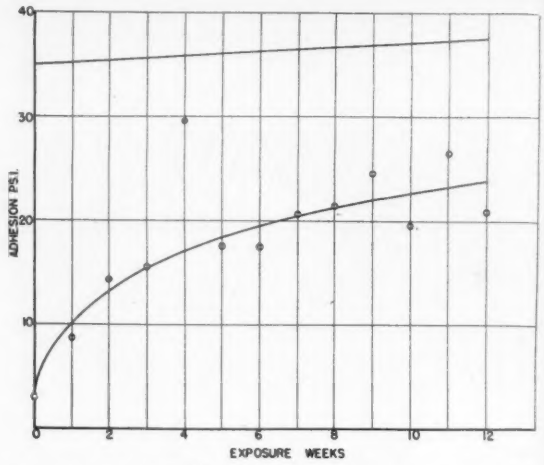

FIG. 18. Deterioration of a silicone film on a De-Icer surface when exposed to Mount Washington summer weather (no protecting ice film). Adhesion tests by centrifugal device[2] at −20°C. Each point is the average of four tests.

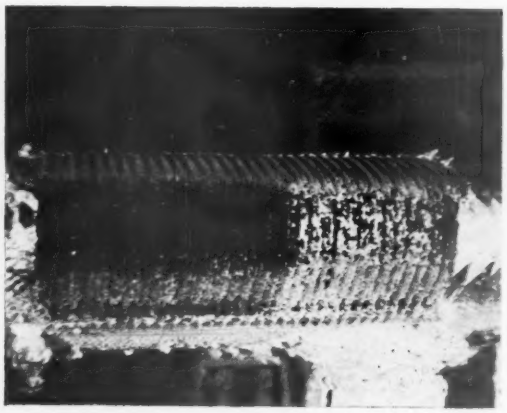

FIG. 19a. The outboard end had been treated. The photograph was taken while the alternate 0.5-in. chordwise tubes of the cemented down De-Icer were inflated with 45 lbs. per sq.in. air pressure.

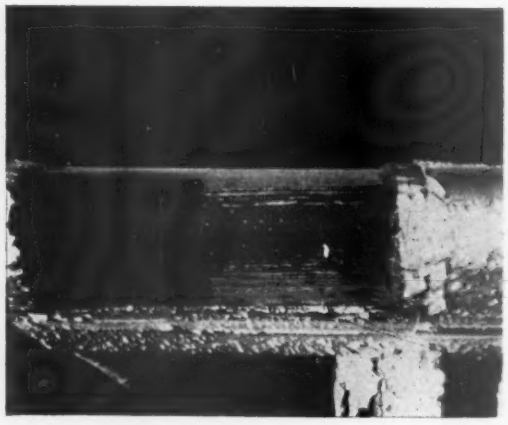

FIG. 19b. A more typical picture of a small tube De-Icer, 0.5-in. tubes, spanwise, 70 lbs. per sq.in. inflation pressure. The frostlike deposit on the outboard end was collected while the tubes were inflated. In many cases the surface was the glossy black of the Neoprene coat.

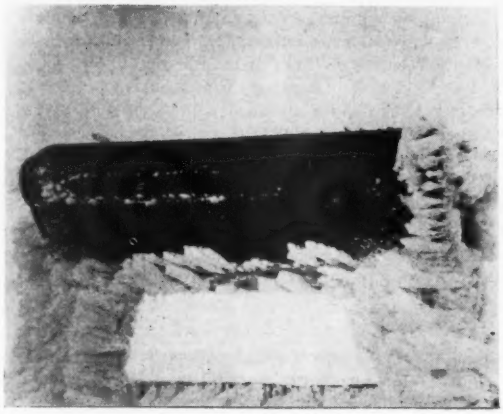

FIG. 20. Continuous operating for 3 hours in light icing. The treated half (*right*) kept clear of ice. The untreated half became no worse than after the first inflation. The ice around the edges is on the supporting framework and serves as a measure of the ice that has been removed. Ice along the tube edges can be clearly seen.

Small Tube De-Icer

To examine the merits of small tubes, several De-Icers have been built using tubes with diameters varying from $^1/_4$ to $^3/_4$ in., with tubes running either chordwise or spanwise. Pressures up to 90 lbs. per sq.in. were used for $^1/_2$-in. tubes. The devices were completely cemented to the wing entirely eliminating the "stretch area." A photograph taken after one cycle is shown in Fig. 19, and the overall operation is illustrated by curve 2 in Fig. 15. Using a rating of 80 per cent as the criterion of perfection, the small tube De-Icer is 37 per cent better than the untreated and even 7 per cent better than the treated Type 12. When the small tube device is treated with silicone, the performance is remarkable (curve 1). This arrangement would probably give completely satisfactory operation in all ice met in flight. Rapidly forming ice at any temperature could easily be removed, and trouble could be expected only for extremely low-density ice, ice that resembles frost or snow. From published reports it appears that heat anti-icing is particularly effective for moderate ice accretion rates (density is of no concern) and that trouble could be anticipated only at extremely high icing rates at low temperature.* The two devices are limited by almost opposite conditions.

Continuous Operation

Many of the experiments were performed by noting the removal following one cycle of operation. This is a satisfactory method for the observer, but, to investigate the variables introduced by continuous operation, a number of experiments were run with the De-Icers cycling automatically for many hours. Changes in the residual ice could usually be traced to changes in the meteorological factors. Or stated in another way, the De-Icer normally did not permit ice to accumulate but adversely, the residual ice left after the first cycle was not removed significantly. Fig. 20 shows photographs of De-Icers taken after 3 hours continuous operation in a light icing storm and illustrates the observations made.

The generalities cannot be tied down too specifically since the performance did depend on ice type and cycle rate. For complete removal the ice film must have a certain minimum strength. The best cycle rate is that which operates each time the ice builds to this thickness. Besides the speed of flight, drop size, liquid water content, and wing shape, the best rate depends on De-Icer design. The better De-Icer requires less time. Such a composite quantity is almost impossible to study under the conditions met on the mountain. Over all the implication seems to be that under the conditions considered the rate at which the De-Icers are cycled is not important. Perhaps if drag could be used as a measure of performance some differences could be detected.

Crystallization

When the De-Icer is exposed to temperatures in the neighborhood of 0°F. under the normal installation tension for 3 or 4 days the tubes become stiff and leather-like. They inflate and deflate so slowly as to be useless as De-Icers. Once they are warmed the usual properties return. This is a manifestation not of the stiffening of rubber at the second order transition (−65°C.) but of crystallization. This set of conditions is met so infrequently in normal operation as to be of little practical importance. Because the small tube De-Icer is installed without tension it does not crystallize unless exposed to this optimum temperature for a matter of months.

Pressure

When smaller tubes are used the required pressure is higher by a factor approximately proportional to the

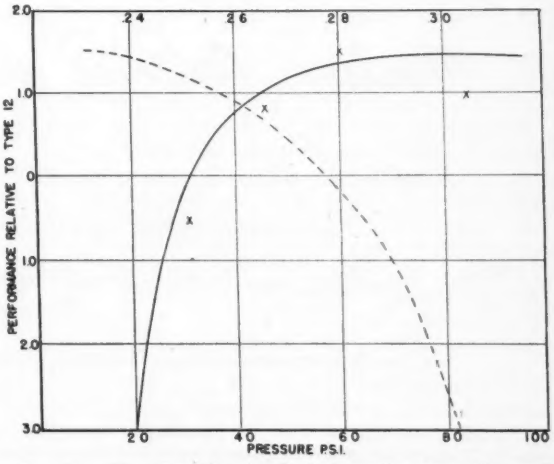

FIG. 21. The effect of pressure on the performance of a small tube De-Icer. The performance is calculated as a difference in ratings assigned to the small tube construction and the Type 12; a rating of 10 is complete removal. The dotted curve and the upper ordinate refer to the radius of curvature in inches. Better small tube De-Icers have been made.

* In one case 11,000 B.t.u. per hour per sq.ft. was insufficient to keep an airfoil free of ice on Mount Washington. Guibert, A. G., Trans. A.S.M.E. Vol. 69, p. 829, 1947. See also Schaefer, V. J., ibid., Vol. 69, 843, 1947.

tube diameter. Fig. 21 indicates the pressure at which $^1/_2$-in. tubes are just equal in performance to a standard Type 12 De-Icer and the improvement achieved by using higher pressure.

ACKNOWLEDGMENT

In planning and executing these tests we have had considerable help from men experienced in rugged mountain-top operations. We wish to acknowledge the aid of Dr. C. F. Brooks, President; Mr. Joseph B. Dodge, the Managing Director and Treasurer; and Messrs. Victor F. Clark, Kenneth E. Gould, and Raymond E. Falconer, all of the Mount Washington Observatory staff; the members of the Yankee Network Station; and Mr. Maurice Staples, manager of the Glen House at the base. The members of the General Electric Company Project, especially Mr. Vincent J. Schaefer, have been particularly cooperative. Where physical hardships are great these aids are essential. Acknowledgment is also made of the work of Messrs. Philip Bettler and John D. Alden, who took many of the observations reported here. Appreciation is also expressed to the other members of this laboratory for extensive aid, especially Mr. D. H. Cornell who designed much of the equipment and Mr. J. M. Davies whose continuous interest and faith made the work possible.

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Feature Articles in Forthcoming Issues

"Application of Servo Systems to Aircraft," by John R. Moore, North American Aviation, Inc.

"Inert Gas Installation," by H. W. Naulty, Cornell Aeronautical Laboratory

"Propeller Considerations for High- Speed Aircraft," by Harold H. Warden, Propeller Division, Curtiss-Wright Corporation

A Symposium—Flight Handling Characteristics of a Modern Transport Airplane

I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

Some Results of Boundary Layer Control Tests in Flight and in the Wind Tunnel*

By

H. B. Dickinson

Lockheed Aircraft Corporation

Between 1941 and 1946 an investigation was conducted at the Lockheed Aircraft Corporation to determine whether it was advisable to attempt an early application of boundary-layer control to an airplane project. The emphasis throughout the investigation was on obtaining drag decreases, as the effect on lift was rather well established and was considered insufficient by itself to justify the complication and weight involved.

After design studies, the investigation was confined to the use of a single spanwise suction slot on the upper surface of a low-drag airfoil of conventional thickness and plan form.

The experimental investigation was divided into three phases. First, a series of tests was made to determine the magnitude of the aerodynamic losses in the slot and duct system and to ascertain whether satisfactory spanwise distribution of suction could be obtained. Secondly, tests were made in the Lockheed Wind Tunnel on a wing section with suction. Finally, flight tests were made with suction applied to an envelope covering a portion of the outer wing of a test airplane, providing drag results at full scale and at high subcritical speeds.

The slot and duct tests show that the internal aerodynamic losses can be low with ducts of practical size in wings of normal thickness and plan form and that satisfactory span distribution can be obtained on such ducts; however, the structural and weight problems are great and the development of such systems would appear to require a lengthy and meticulous experimental program. The wind-tunnel and flight results indicate substantial drag reductions including the effect of the power required to provide the suction.

The resulting total drags do not appear particularly attractive, however, by comparison with drags known to be attainable with wings of sufficient smoothness. Accordingly it appears that the simpler problem of obtaining sufficient smoothness of actual wings should be solved first. Thereafter, the drag reduction by boundary-layer control appears less promising, and to make the added complication worth while would require capitalizing on all of the potential advantages, including lift increase for landing and maneuvering, propulsive efficiency increase, the possible drag reduction at supercritical speeds, the use of wing sections thicker than the optimum without suction, and the lessening of the sensitivity of low-drag airfoils to accidental roughness and turbulence.

* Presented at the Annual Summer Meeting, I.A.S., Los Angeles, July 14–16, 1948.

Please do not order Preprints of these papers at this time.

See page 55 for Preprints that are immediately available.

Servo Systems for Aircraft*

By

John R. Moore

North American Aviation, Inc.

The paper begins with the prognostication that the age of flight we are now entering can be profitably served by various types of electromechanical devices which act as though they have brains and nerves, as well as muscles. These mechanical servants are called servomechanisms, several of which may be combined into servo systems. Their present and future use in aircraft as control boosters, automatic pilots, automatic engineers, and automatic navigators is mentioned with the prediction that, as airplanes become larger and flight faster they will be taken off, navigated along a predetermined course, controlled in the air, and landed at a specified destination entirely automatically.

The purpose of the talk is expressed as explaining the basic ideas of servomechanisms, interpreting the specialized jargon that has grown up around them, outlining present-day methods of servo analysis and synthesis, emphasizing shortcomings of these methods, and predicting what future trends will be.

A pitch control automatic pilot is selected as a vehicle for explaining basic ideas. The development here follows the efforts of a hypothetical aeronautical engineer to develop the "first" automatic pilot. Basic elements of a servo system are developed in parallel with corresponding elements in a human pilot. Methods of analysis, together with limitations and pitfalls which are liable to accompany such methods, are presented. The advantages of borrowing techniques from the design of feedback amplifiers are explained, and such techniques are briefly described. Limitations of such techniques and practical difficulties, which serve to distinguish the idealized servomechanism from the practical device, are emphasized.

* Presented at the Annual Summer Meeting, I.A.S., Los Angeles, July 14–16, 1948.

Probable future trends in servo design depend upon the development of engineering aid computing devices such as digital computers and simulators. Problems of increased complexity involving several inputs and outputs are considered as logical extensions of present developments. The greatest single missing link is considered to be the systematic treatment of the effects of unwanted disturbances, and major advances in precision servos of the future may be expected to accompany the development of methods for detecting, classifying, and minimizing such disturbances.

Primary Instability of Open-Section Stringers Attached to Sheet

By

Samuel Levy and Wilhelmina D. Kroll

National Bureau of Standards

A method is presented for predicting the primary instability of open-section stringers attached to sheet. The method extends the torsion bending theory to take account of the stabilizing effect of the sheet to which the stringer is fastened. The effects of the sheet in restraining, twisting, and warping of the stringer, as well as in forcing the center of twist to lie in the plane of the sheet, are considered. The method is checked by comparing computed and observed values of maximum load for sheet-stringer panels reinforced by *Z*-section stringers. The load carried by the sheet in these panels was computed from a nomogram derived for a previous investigation. Experimental data from two groups of unpublished test results and from three other investigations are included in the comparison.

Testing of Jet Propulsion Engines Under Simulated Air-Speed and Altitude Conditions*

By

J. F. Manildi

G. M. Giannini and Company, Inc.

The testing of jet engines and air ducting systems in either open or closed wind tunnels presents serious problems. In closed tunnels the problems of dissipation of the heat generated within the engines and the interference due to tunnel walls are nearly insurmountable. In open tunnels the power required to ensure a stream of sufficiently large cross section is extremely large. In both cases the problem of evaluating the internal airflow poses a formidable problem, which, in the case of pulsating flow engines, cannot be satisfactorily solved with any degree of accuracy.

Most of the problems outlined above may be avoided by the use of pressurized tanks, to which the engine being tested may be directly attached. The effect of both forward air speed and altitude can be simulated in this fashion. The installation costs and power requirements for such an installation are much lower than for a tunnel installation. The evaluation of the internal performance of the engine from the test data is vastly simplified.

The system of using pressurized tanks is, of course, open to the objection that the effects of the external flow on the internal performance, if such effects exist, are not accounted for. This objection is a valid one. However, it is felt that the advantages of such a system far outweigh the disadvantages.

* Presented at the Annual Summer Meeting, I.A.S., Los Angeles, July 14–16, 1948.

General Status of Work at J.P.L.*

By

Louis G. Dunn

California Institute of Technology

The development of rockets and ram-jets as propulsion power plants has given rise to new engineering problems, as well as the broadening of existing engineering knowledge.

The present activities of the Jet Propulsion Laboratory can be divided into essentially three categories—namely, basic engineering research, applied research, and the development of certain specialized test vehicles. It is intended to discuss some of the work that is currently being carried out under the first two categories and will cover the following broad fields:

(A) Rocket Propellants and Rocket Motor Studies.
  (1) Thermodynamics and kinetics of combustion.
  (2) Physical and chemical properties.
  (3) Theoretical performance calculations for both liquid and solid propellants.
  (4) Comparison of theoretical and experimentally obtained performance.
  (5) Performance and heat transfer as a function of geometrical shape.

(B) Air-Fuel Combustion.
  (1) Fluid mechanics of air-fuel combustion.
  (2) Chemistry of air-fuel combustion.

(C) Materials.
  (1) Development of porous metals for sweat-cooling.
  (2) Flow of gas and liquids through porous media.
  (3) Investigation of refractory materials for rocket motors.

(D) Heat Transfer.
  (1) Heat transfer of surface boiling.
  (2) Sweat-cooling with porous materials.

The Optimum Proportions of a Long Unstiffened Circular Cylinder in Pure Bending

By

Herbert Becker

Fairchild Engine and Airplane Corporation

The problem of determining the radius and wall thickness of a minimum weight circular cylinder under pure bending is encountered during the design of a missile fuselage. Selection of any of the three common plastic moduli (secant, reduced, and tangent) for use in the buckling stress equation will yield approximately the same optimum design proportions. Furthermore, small deviations from the optimum design geometry will lead to minor weight increases. A simplified design procedure is presented which depends upon the applicability of the secant modulus theory, for which substantiating evidence is available. However, since it is not conclusive, the use of the simplified design procedure, which yields a near-optimum design with little effort, must be considered uncertain until such a time as further evidence is available to support the secant modulus theory.

In the analysis it is assumed that the buckling stress is linearly proportional to t/R, in agreement with existing data. Discussion of departures from this rule is omitted.

The development, which is entirely analytic, employs the three-parameter method of describing stress-strain curves. This leads to expressions for shell radii and weights which are easily compared for each of the three plastic modulus theories.

* Presented at the Annual Summer Meeting, I.A.S., Los Angeles, July 14–16, 1948.

Plastic Flow Characteristics of Aluminum-Alloy Plate

By

L. J. Klingler and G. Sachs

Case Institute of Technology

Commercial hot-rolled $1^1/_2$-in. 24ST aluminum plate possesses a marked degree of crystallographic anisotropy. Tensile tests at various orientations showed that the yield strength is only slightly dependent upon the crystallographic anisotropy. Ratios of the transverse strains to the longitudinal strain varied from -0.30 to -0.57, while for an isotropic material the ratio would be -0.50.

The Bending Modulus of Rupture of Round Magnesium Tubing

By

C. N. Mortenson

The Dow Chemical Company

Bend tests were conducted on 28 round tubes of FS-1a and Ma magnesium alloy. Each alloy covered the d/t range from 20 to 75. The results are summarized empirically, and the following formula is established as representing a minimum value for the bending strength.

$$f_r \text{ (min.)} = 0.7 F_{cy} \, (Et/F_{cy}d)^{0.25}$$

Unsteady One Dimensional Flows with Heat Addition or Entropy Gradients

By

A. Kahane and Lester Lees

Princeton University

The present interest in aerodynamic propulsive devices, such as the pulse-jet and the ram-jet, has stimulated recent research in the field of combustion. One important aspect of the combustion problem which is considered herein is the unsteady gas dynamic effects associated with the burning process.

Nonlinear differential equations of the Riemann type are derived for the solution of problems involving the propagation of one-dimensional waves in flows in tubes of slowly varying cross section with heat addition or entropy variation. These equations can be solved graphically or numerically with the method of characteristics; the method is described in an appendix. The transient flows arising when heat is added to a section (as in a combustion chamber) of an initially isentropic flow in a tube have been calculated. The results of this calculation afford an insight into the gas dynamic aspects of intermittent heat addition in a flowing gas, as well as to the apparently anomalous behavior at sonic velocity of steady gas flows with heat addition. The equations derived are well suited to the calculation of the nonlinear pulse-jet cycle with heat addition, once a suitable model of combustion has been selected.

I.A.S. National Meeting Schedule

Military Aeronautics Meeting—Dayton, Ohio—October 14–15, 1948

Wright Brothers Lecture—U.S. Chamber of Commerce Auditorium, Washington, D.C.—December 17, 1948

Seventeenth Annual Meeting—Hotel Astor, New York, N.Y.—January 24–27, 1949

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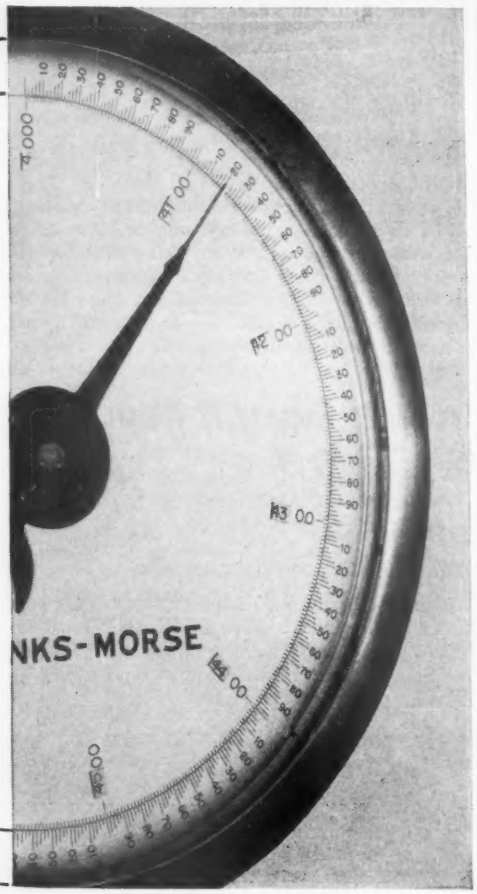

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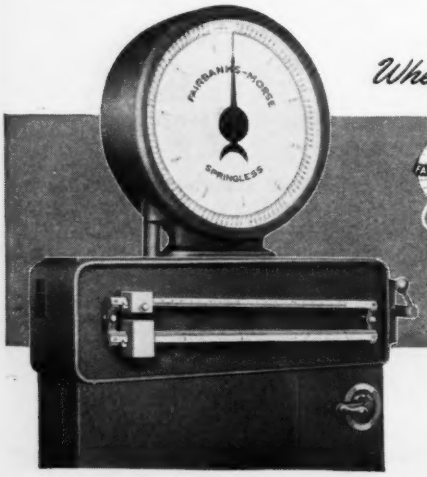

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125 Inert Gas Installation—H. W. Naulty, Cornell Aeronautical Laboratory

130 The Boundary Layer of Yawed Infinite Wings—J. M. Wild, Graduate School of Aeronautical Engineering, Cornell University

131 Linearized Theory of Supersonic Control Surfaces—P. A. Lagerstrom, Assistant Professor, Guggenheim Aeronautical Laboratory, California Institute of Technology, and Martha E. Graham, Douglas Aircraft Company, Inc.

134 The Transient Reaction of a Two-Dimensional Wing at Supersonic Speed Due to Change in Angle of Attack—Chieh-Chien Chang, Associate Professor, Department of Aeronautics, The Johns Hopkins University

No.

136 Stability and Control of Supersonic Aircraft—A. F. Donovan, A. H. Flax, and H. A. Cheilek, Cornell Aeronautical Laboratory

137 Experimental Study of Cooling by Injection of a Fluid Through a Porous Material—Pol Duwez and H. L. Wheeler, Jr., Jet Propulsion Laboratory, California Institute of Technology

138 The Flow of a Perfect Fluid Through an Axial Turbomachine with Prescribed Blade Loading—Frank E. Marble, National Research Council Predoctoral Fellow, Guggenheim Aeronautical Laboratory, California Institute of Technology

139 Service Experience with Turbojets—J. W. Bailey, Head, Engineering Services, Allison Division, General Motors Corporation

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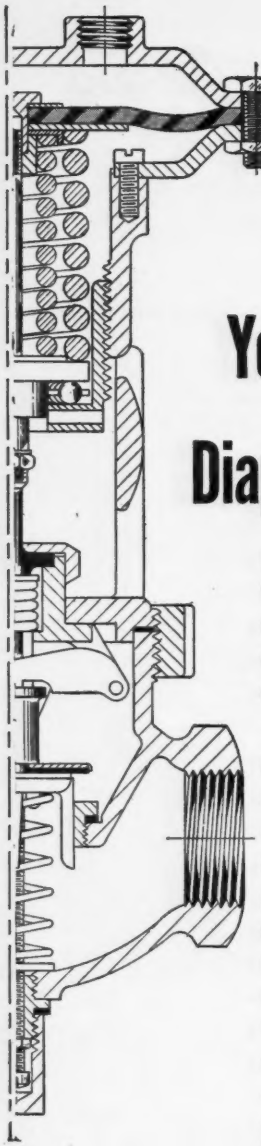

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Aerodynamics (2)

CONTROL SURFACES

Wind-Tunnel Investigation of Seven Thin NACA Airfoil Sections to Determine Optimum Double-Slotted-Slap Configurations. Jones F. Cahill and Stanley F. Racisz. *U.S., N.A.C.A., Technical Note No. 1545*, April, 1948. 75 pp., figs. 6 references.

Wind-tunnel investigation was made to determine optimum double-slotted-flap positions for NACA 63-210, 64-208, 64-210, 64_1-212, 65-210, 66-210, and 1410 airfoils. Optimum fore-flap positions were generally 1 per cent chord forward and 3 per cent chord below the slot lip. Optimum flap positions varied considerably. Maximum lifts decreased as position of minimum pressure moved to the rear and as thickness decreased. Scale-effect tests showed that maximum lifts increased as Reynolds Number was increased from 2.4×10^6 to 6.0×10^6 and changed but slightly above 6.0×10^6.

Collection of Test Data for Lateral Control with Full-Span Flaps. Jack Fischel and Margaret F. Ivey. *U.S., N.A.C.A., Technical Note No. 1404*, April, 1948. 180 pp., diagrs. 35 references.

A compilation of data on the lateral control effectiveness and hinge moment of full-span flaps. The flap designs include slot-lip and flap-trailing-edge ailerons, spoiler-type ailerons other than slot-lip ailerons, and ailerons with retractable flaps. Much of the data for ailerons with retractable flaps was obtained on models equipped with duplex flap arrangements. Since the outboard flap of such arrangements usually retracts into the airfoil contour ahead of the aileron for the flap-up configuration, the data is representative of and may be used in the design of retractable-flap ailerons. The data have not been correlated to provide design charts, but it should facilitate the design of full-span flap lateral-control arrangements. A general discussion treats the characteristics of the devices and their application in specific aircraft.

Collection of Balanced-Aileron Test Data. F. M. Rogallo. *U.S., N.A.C.A., Advance Confidential Report No. 4A11 (Wartime Report No. L-419)*, January, 1944. 216 pp., diagrs., figs. 34 references.

Compiled test data collected from N.A.C.A. and British sources. Five types of airfoil are included: ailerons with Frise balances, ailerons with blunt nose balances, ailerons with internal balances, ailerons with contour modifications, and ailerons with tabs. The results of flight and wind-tunnel tests in both two-dimensional and three-dimensional flow are given in chart form. Supplementary information on the models and on the test conditions is tabulated. The table includes published references and serves as an index to the data presented, since the model or airplane designation is given in the first column of the table and in the upper right-hand corner of each page of model drawings or test results. No correlation or résumé of the data is included in this publication.

Wind-Tunnel Investigation of Effects of Forward Movements of Transition on Section Characteristics of a Low-Drag Airfoil With a 0.24-Chord Sealed Plain Aileron. Stanley F. Racisz and Jones F. Cahill. *U.S., N.A.C.A., Technical Note No. 1582*, May, 1948. 26 pp., figs. 5 references.

Effects of forward movements of transition on section characteristics of 0.12c-thick low-drag airfoil with 0.24c sealed plan aileron at Reynolds Number of 14×10^6 are presented. For this airfoil and aileron, fixed transition at either 0.30c or leading edge caused aileron effectiveness to decrease, negative rate of change of section hinge moment with angle of attack and with aileron deflection to decrease, and life-curve slope to decrease slightly. Shifting of the position of transition from about 0.50c to 0.30c generally caused larger changes in aileron characteristics than those caused by shifting from 0.30c to the leading edge.

Investigation in the Langley 19-Foot Pressure Tunnel of Two Wings of NACA 65-210 and 64-210 Airfoil Sections With Various Type Flaps. James C. Sivells and Stanley H. Spooner. *U.S., N.A.C.A., Technical Note No. 1579*, May, 1948. 59 pp., illus., figs. 3 references.

An investigation was conducted in the Langley 19-ft. pressure tunnel to determine the maximum lift and stalling characteristics of two thin wings equipped with several types of flaps. Split, single-slotted, and double-slotted flaps were tested on one wing that had NACA 65-210 airfoil sections and split and double-slotted flaps were tested on the other, which had NACA 64-210 airfoil sections. Both wings had zero sweep, an aspect ratio of 9,

and a ratio of root to tip chord of 2.5. Wings were tested with and without a representative fuselage and with and without leading-edge roughness.

Wind-Tunnel Investigation of the Boundary Layer on an NACA 0009 Airfoil Having 0.25- and 0.50-Airfoil Chord Plain Sealed Flaps. Jack D. Brewer and Josephine F. Polhamus. *U.S., N.A.C.A., Technical Note No. 1574*, April, 1948. 53 pp., figs. 12 references.

Two representative airfoil-flap configurations were examined as part of an extensive investigation of control-surface characteristics. The measured velocity profiles and the boundary-layer parameters determined from them are presented. Data from this investigation are to be used to obtain a more accurate method for predicting the boundary layer in the region of the trailing edge, in order to correlate measured hinge moments and calculated boundary-layer parameters.

Slots: Advantage and Disadvantage. Robert McLarren. *Aviation Week*, Vol. 48, No. 16, April 26, 1948, p. 24. 1 reference.

Open slots in the leading edge of the wing reduce the stalling speed of an aircraft and minimize its tendency to spin. Once the spin has begun, however, slots retard recovery. Since the magnitude of this latter effect depends on the mass distribution on the air frame, the relative advantage or disadvantage of the use of slots can be determined by aircraft design.

FLUID MECHANICS & AERODYNAMIC THEORY

Steady Two-Dimensional and Rotationally-Symmetric Supersonic Flows. W. Tollmien. (*Dresden, Technische Hochschule, Peenemünde Archiv Nr. 44/1–44/6*, 1940.) *Brown University, Graduate Division of Applied Mathematics, Translation No. A9-T-1 (Advance Copy)*, 1948. 151 pp., tables. 16 references.

A mathematical exposition of the development and solution of the formulas for two-dimensional and rotationally-symmetric steady supersonic flows. In addition to summarizing published literature, the work embodies the results of original research by the author and attempts to present the whole in a form that will make the data accessible to the workers in this field. The differential equations for the velocity field are expressed in dimensionless variables and applied to two-dimensional flows and rotationally symmetric flows. Because of its importance, the theory of characteristics is given a fundamental treatment, and an approximate solution of the characteristic differential equations is constructed by the method of lattice points. The construction is also made by the method of meshes. The last method follows upon a treatment of the general case made possible by a suitable definition of the center of the mesh. The method of using tabulated results for Prandtl-Meyer flows around a corner in the approximate calculation of two-dimensional potential flows is given in a more general form than heretofore, and the theory of compression shocks is expressed in a parametric form that lends itself readily to calculations. The appendix contains a table showing the relation between deflection, pressure, velocity, Mach Number, and Mach angle for adiabatic changes of state according to Prandtl-Meyer and three tables for constructing gas flows which give the velocity of sound, the ratio of the velocity of sound to the velocity of the flow and the Mach angle as functions of the flow velocity, and the pressure ratio as a function of the flow velocity. The bibliography contains brief notes on the importance of each reference and its correlation with present work. The translator has carefully provided explanatory footnotes, where the concept represented by the original German expression contains an extension, or a nuance, not encompassed by the English term.

Remarks on the Work: "Two Boundary Value Problems in the Theory of Hyperbolic Partial Differential Equations of the Second Order With Applications to Supersonic Gas Flow" By F. Frankl and R. Aleksyiva (Moscow). M. Schaefer. (*Dresden, Technische Hochschule, Peenemünde Archiv 44/2a*, June 1, 1944.) *Brown University, Graduate Division of Applied Mathematics, Translation No. A9-T-4 (Advance Copy)*, 1948. 6 pp.

Starting with the differential equations for the velocity potential of stationary, compressible, irrotational flow, the basic paper establishes the corresponding characteristic equations. By choosing for coordinates the characteristic curves, a system of five equations, linear in the derivatives, is obtained. If the determinant of the coefficients of this system of partial differential equations for the cases of mixed boundary value problems that occur in gas dynamics are assumed not to vanish, a unique solution can be demonstrated. Assuming that the determinant of coefficients does not vanish excludes two cases: that in which the left and the right Mach waves coincide, and that in which one of the two Mach waves intersects the x-axis perpendicularly. Since this second case cannot be avoided by suitable orientation of the coordinate system when dealing with rotationally symmetrical flow and since no corresponding physical peculiarity exists, the proof given in the basic paper requires modification.

The Aerodynamics of Porous Sheets. G. I. Taylor and R. M. Davies. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2237*, April, 1944. 14 pp., tables. 6 references. British Information Services, New York. $1.00.

Measurements were made with perforated sheets, metal grids, wire gauzes, and sheets of fabric to determine the relation between the coefficient of drag of such materials and their resistance coefficients. Current theories as to the relation existing between the porosity of a sheet and the ratio of the area of the holes to the total area of the sheet postulate a pressure recovery downstream of an arbitrary fraction of the kinetic energy in the apertures. Test results indicated that the jets recover a constant proportion of their kinetic energy.

Theoretical Analysis of Stationary Potential Flow and Boundary Layers at High Speed. K. Oswatitsch and K. Wieghardt. (*Lilienthal-Gesellschaft für Luftfahrtforschung, Bericht Nr. S 13, 1. Teil*, pp. 7–24.) *U.S., N.A.C.A., Technical Memorandum No. 1189*, April, 1948. 59 pp., illus., figs. 12 references.

A simplified equation of gas dynamics for two-dimensional stationary flows with local supersonic zones is derived, using the energy theorem rather than the adiabatic formula. The numerical-graphical solution of this equation starts from an exact solution at great distances from the body and progressively calculates the entire flow, finally obtaining the exact body form from the shape of the streamlines. Although the method is not adequate to obtain the flow around a finite body with a stagnation point, it is valid for a wide range of Mach Numbers, including the transonic zone. Formulas for the variation with velocity of the displacement thickness of laminar and turbulent boundary layer are used to refine the calculation of potential flow with a supersonic region. The flow is calculated about a substitute body that has approximately the same displacement effect, dead-water region, and boundary-layer displacement effect. Calculations show a strong increase in velocity at the nose of the body and a strong decrease at the point where the curvature of the substitute body disappears.

Note on Similarity Conditions for Flows With Heat Transfer. Albert E. Von Doenhoff. *U.S., N.A.C.A., Technical Note No. 1577*, April, 1948. 14 pp., figs. 7 references.

The experimental procedure for tests simulating flight at high Mach Numbers may be simplified by divorcing the fluid heat-conduction problem from the heat-radiation problem and interpreting wind-tunnel results in the light of the similarity conditions that exist for flows of a compressible fluid with heat transfer. For similar flows to be possible at various values of the stagnation temperature and for models of various scales, the gas must have a ratio of heat conductivity to viscosity independent of temperature or at least of the same value or corresponding points for model and flight conditions. The specific heat must be constant or the same for corresponding points, and the temperature coefficient of volume expansion must be inversely proportional to the absolute temperature. The maintenance of corresponding local values of the flow parameters with variations of stagnation temperature and model scale requires that the free-stream velocity be proportional to the square root of the stagnation temperature. The kinematic viscosity must be proportional to the product of the model scale and the square root of the absolute stagnation temperature. The range of the stagnation temperatures over which similar flows are possible in air is limited by variations with temperature of the ratio of heat conductivity to viscosity and the ratio of specific heat at constant pressure to that at constant volume.

The Laminar Mixing Motion of Two Incompressible Gases. P. Y. Chou. *Chinese Journal of Physics*, Vol. 7, No. 2, December, 1947, pp. 96–101. 3 references.

Equations determining the velocity and density distributions within the mixing region of two incompressible gases with different densities are set up with the assumption that their temperatures are the same. For incompressible mixing the total number of gas molecules per unit volume is constant, although the density of the gaseous mixture varies from point to point because of diffusion of matter. As an illustration the plane jet and steady motion is considered. The boundary-layer method of approximation can still be applied. The boundary of the jet is shown to be the same as that for one fluid. The solution of the problem then

depends upon the numerical value of the coefficient of viscosity of the mixture, which is a function of the number of molecules of each constituent gas in the unit volume. The present method of investigation is applicable to cylindrical and half jets and also to the case where the two gases are at different temperatures.

INTERNAL FLOW

Analysis of Heat and Compressibility Effects in Internal Flow Systems and High-Speed Tests of a Ram-Jet System. John V. Becker and Donald D. Baals. *U.S., N.A.C.A., Report No. 773*, 1943. 45 pp., illus, figs. 8 references. U.S. Govt. Printing Office, Washington. $0.30.

Equations and charts were developed, based on the assumption of one-dimensional compressible flow, from which it is possible to determine the characteristics at key stations in a typical aircraft internal ducting system. The extremely high Mach Numbers that must be attained within the fins of existing air-cooled engines at high altitudes cause compressibility effects and attendant density decrease and pressure drop that are considerably greater than the values computed on a basis of incompressible flow. When a Mach Number of 1.0 is reached at any station, the flow becomes choked and further reduction of outlet pressure will not increase the flow rate. The addition of heat to the system has a throttling effect that leads to choking at lower rates of flow. Wind-tunnel tests of a ram-jet propulsion system between Mach Numbers 0.2 and 0.75 verified these calculations and showed the measured thrusts and thermal efficiencies of the ram-jet system approached the ideal. The efficiency of the propulsive effect due to heating the internal flow depended mainly on the ratio of the static pressure in the duct behind the radiator to the stream static pressure and, to a lesser extent, on the Mach Number of the duct flow and the rate of heating.

Discharge Coefficients of Chamfered Orifices and Nozzles. R. A. Collacott. *Aircraft Engineering*, Vol. 20, No. 230, April, 1948, pp. 112, 113, figs.

A series of experiments established that the discharge coefficient of a nozzle increases gradually as the angle of bevel is increased until it reaches a maximum value of 0.95 at an angle of 95°. The angle of chamfer for which the coefficient is maximum becomes less acute as the head is lowered, and the maximum discharge coefficient tends to decrease with decrease in the head. For thin-plate orifices the discharge coefficient rises rapidly as the angle of chamfer increases and is maximum at an included angle of 55°. As the angle is further increased, the coefficient decreases. For thin-plate orifices the maximum discharge coefficient increases almost linearly with decrease in the head.

On the Aerodynamic Design of Axial-Flow Compressors and Turbines. Andrew Vazsonyi. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 53–64, illus., diagrs., figs. 3 references.

A theoretical method for determining the flow of a perfect (frictionless, incompressible) fluid across a cascade built up of arbitrary airfoils. The presentation refers to compressor blading but is immediately applicable to turbine blading. The lift-coefficient curve as a function of angle of attack (or deflection-angle curve) of an arbitrary cascade can be determined in about 10 man-hours. The complete investigation of all possible cascades built up of a given airfoil (any solidity and any stagger) requires about 60 man-hours. The procedure is graphical and standardized to the extent that no mathematical knowledge is required of the computer. Agreement between theory and tests is excellent. By an extension of the method the detailed pressure and velocity distribution of the flow can be obtained.

The Influence of the Diameter Ratio on the Characteristics Diagram of the Axial Compressor. B. Eckert, F. Pflüger, and F. Weinig. (*Stuttgart, Technische Hochschule, Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren.*) *U.S., N.A.C.A., Technical Memorandum No. 1125*, April, 1948. 55 pp., illus., diagrs., figs.

Tests on a single-stage axial blower with a variable diameter ratio gave a decrease in both the maximum attainable pressure coefficient and the throttle coefficients as the diameter increased. The optimum efficiency that could be attained depended on the specific rotary speed and the quantity coefficient related to the obstructed tubular cross section. This efficiency always decreased as the diameter ratio increased. The calculated adiabatic efficiency agreed well with the test results and was extremely sensitive to the drag-lift ratio of the blades. The results also showed that the optimum internal efficiency depended on the flow coefficient and the diameter ratio.

Inlet Conditions of Centrifugal Compressors for Aircraft Engine Superchargers and Gas Turbines. H. Woodhouse. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 403–406, figs. 4 references.

At relative air inlet air velocities greater than 1,400 ft. per sec. and at comparable Mach Numbers for the various freons, the increase that is required in the vane inlet angle needed to compensate for choking and to provide an effective area equal to the design value can become critical. Test results indicate that this increase, or angle of attack, is optimum at 4°. Curves are derived by which the inlet velocity may be corrected for the change in density which is caused by the acceleration of the air as it approaches the impeller inlet. With this velocity it is possible to determine the proper theoretical inlet vane angle and the actual vane inlet angle.

Calculation of Diffuser Efficiency for Two-Dimensional Flow. R. C. Binder. **Discussion.** Donald Ross and J. M. Robertson. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, p. 81. 7 references.

Design and Performance of Family of Diffusing Scrolls With Mixed-Flow Impeller and Vaneless Diffuser. W. Byron Brown and Guy R. Bradshaw. *U.S., N.A.C.A., Technical Note No. 1568*, May, 1948. 30 pp., figs. 3 references.

Compressor efficiency and pressure ratio were higher over a more extended range than with a vaned diffuser and a collector ring. The variations in scroll geometry had a negligible effect on compressor performance.

An Introduction to an Analysis of Gas Vibrations in Engine Manifolds. R. C. Binder and A. S. Hall, Jr. **Discussion.** E. C. Magdeburger, E. F. Murphy, V. J. Skoglund, and J. D. Swannack. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, p. 82. 10 references.

Aerodynamics of the Carburetor Air Scoop and the Engine Cowling of a Single-Engine Torpedo-Bomber-Type Airplane. John K. Kuenzig and Herman Palter. *U.S., N.A.C.A., Memorandum Report No. E6E27* (*Wartime Report No. E-280*), June, 1946. 34 pp., illus., figs. 1 reference.

PERFORMANCE

The Fallacy of Arbitrary Performance Regulations. F. W. Kolk and R. W. Ayer. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting, New York*, April 13–15, 1948. 8 pp., fig.

An analysis of section O4B of the Civil Air Regulations, the minimum standards of acceptable performance for passenger-transport aircraft, shows that the requirements are unduly restrictive and impose a penalty on the performance and on the economical operation of many aircraft that are obviously safe. The DC-3, which does not operate under these regulations, has no extensive record of accidents caused by this noncompliance. While regulations must, by their nature, be arbitrary, they should be limited to such basic essentials as the ability to clear obstacles after engine failure and the ability to maneuver safely under emergency conditions.

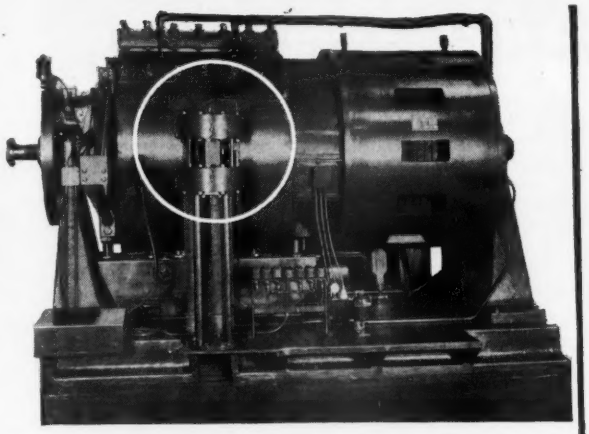
A Further Development in Calculating the "Take-Off to 50 Ft." Distance of an Aeroplane. *Aircraft Engineering*, Vol. 20, No. 230, April, 1948, pp. 98–101, figs. 3 references.

Propeller thrust in the take-off range is expressed as a function of speed in order that the ground run may be integrated directly. The compact formulas given may be manipulated to estimate the various stages comprising the total "take-off to 50 ft." distance. When the drag of an aircraft has been estimated, the take-off distance can be obtained with a fair degree of accuracy and the effects of the various parameters can be determined.

Analysis of Cooling Limitations and Effect of Engine-Cooling Improvements on Level-Flight Cruising Performance of a Four-Engine Heavy Bomber. Frank E. Marble, Mahlon A. Miller, and E. Barton Bell. *U.S., N.A.C.A., Memorandum Report No. E6B07* (*Wartime Report No. E-275*), March, 1946. 35 pp., illus., figs. 11 references.

STABILITY & CONTROL

Dynamic Lateral Stability as Influenced by Mass Distribution. Leonard Sternfield and Marion O. McKinney, Jr. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 411–417, figs. 8 references.



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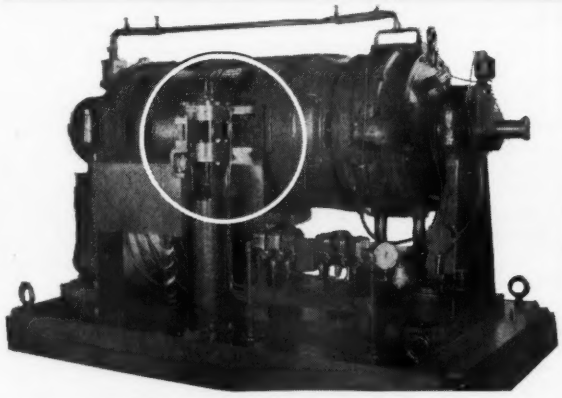

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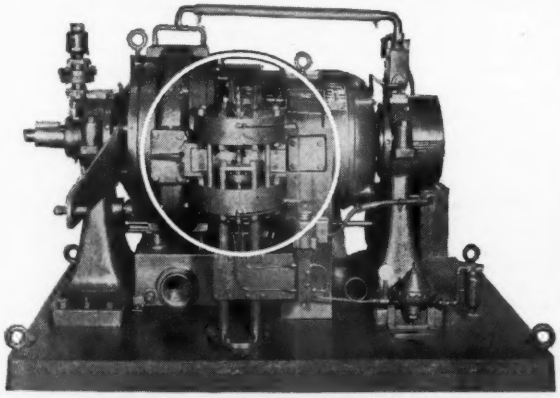

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A résumé of theoretical and experimental investigations to determine the effects of mass distribution on dynamic-lateral stability of aircraft. The effects of varying the wing loading, the rolling and yawing moments of inertia, and the inclination of the principal longitudinal axis of inertia relative to the flight-path axis are illustrated by specific examples for which calculated oscillatory-stability boundaries or time histories of the lateral oscillations are given. Small angles of inclination of the principal longitudinal axis of inertia relative to the flight path cause a pronounced increase in the oscillatory stability. Further increases in the angle of attack, however, do not result in proportionate increases in the oscillatory stability. Oscillatory lateral stability is reduced by an increase in wing incidence and by a simultaneous or independent increase in the rolling or yawing moments of inertia. An increase in wing loading or altitude generally causes an appreciable reduction in lateral stability, but in cases of high wing loadings and altitudes, variation of these factors has virtually no effect on the oscillatory stability.

Stability Derivatives: Determination of l_p by Free Oscillations. J. M. Evans and P. T. Fink. *Australia, Council for Aeronautics, Report No. ACA-34*, April, 1947. 11 pp., illus., figs. 6 references.

Description of the test setup used to study the rolling derivative of a model airplane which is caused by rate of roll by the free oscillation method. Both motion-picture photography of a moving pointer and stylus tracing on a rotating disk were cumbersome and required too many readings for satisfactory accuracy. The results showed no scale effect on the derivative over the range of Reynolds Numbers covered. It seems also that the derivative is independent of aileron deflection and increases with frequency of oscillation, as determined by the free oscillation method.

On Fundamental Sets of Solutions of the Equations of Lateral Motion, and the Rapid Calculation of General Solutions. K. Mitchell. *Gt. Brit., Aeronautical Research, Reports and Memoranda No. 2182*, May, 1945. 28 pp., figs. 4 references. British Information Services, New York. $1.60.

Seven fundamental solutions are defined for the lateral motion of a symmetric airplane slightly disturbed from steady flight. These solutions are obtained to the first order of small quantities from a system of six simultaneous linear differential equations with constant coefficients in which the inhomogeneous terms representing control forces or the effects of gusts may be arbitrary functions of time. A large number of sets of fundamental solutions has been obtained by means of the differential analyzer, which may be used to obtain solutions corresponding to the constant, or piecewise constant disturbance or disturbance given as a function of time. Particular examples of the technique are given, and an index in tabular form is included to the complete series of 1,188 figures in which the differential analyzer results are contained.

THERMO-AERODYNAMICS

Heat Transfer to Bodies Traveling at High Speed in the Upper Atmosphere. Jackson R. Stalder and David Jukoff. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 381–391, figs. 14 references.

A study of the heat-transfer processes occurring in the region of free molecular flow. A method is developed by which the surface temperatures of uncooled bodies traveling at any speed in a rarified gas may be determined. Assuming that the mean free path of a molecule at an altitude of 75 miles is 1 ft., calculations for altitudes greater than 75 miles show that, if solar radiation is absent, the skin-cooling problem of high-speed missiles becomes negligible above 100 miles altitude at steady flight speeds up to 20,000 ft. per sec. with body angle less than 20°. At this velocity the effect of solar radiation on skin temperatures is small at 75 miles, but as the altitude increases, it becomes increasingly important until at 150 miles it is the predominant factor. Thus, with solar radiation, the effect of the emissivity of the body on its temperature decreases in importance as the altitude increases, becoming negligible at 150 miles. The use of a high fineness ratio will minimize skin temperatures by keeping the body angle as small as possible. Skin temperatures may be reduced by ensuring thermal contact between portions of the body inclined at positive and negative angles with respect to the flight path and by boat-tailing the body to incline a maximum surface at a negative angle.

WINGS & AIRFOILS

The Rolling Moment Due to Sideslip for a Swept Wing. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 418–424, figs., tables. 8 references.

The rolling moment coefficient due to sideslip is computed for a swept wing by the strip theory. Multhopp's theory for a wing in sideslip and a modification of Prandtl's elliptic wing theory are used to correct this result for induction effects, and the effects of geometrical dihedral, twist, camber, elevons or flaps, and fuselage on the accuracy of this result are examined. Upon comparison with experimental data it is found that Weissinger's value of the rolling moment coefficient due to sideslip for a straight wing, if added to the result for a swept wing, gives satisfactory agreement

Methods of Calculating Derivatives for Rectangular Wings. W. P. Jones and Sylvia W. Skan. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2215*, September, 1940. 15 pp., figs. 5 references. British Information Services, New York. $1.00.

A method of calculating the aerodynamic forces on an oscillating wing in which each sheet of Lyon's vortex system is replaced by a distribution of infinite vortex filaments and a system of angular vortices. A relatively simple expression is obtained for the induced velocity at any point on the wing by which the induced velocity at various points on the wing can be calculated and the vorticity distribution obtained by satisfying the velocity condition at a number of points over the wing area. Approximate forms of this theory assume the chordwise distribution of velocity in any section to be proportional to the values obtained by two-dimensional theory. The rate of convergence of this method is fairly rapid. The moments on a rectangular wing of aspect ratio 6 oscillating symmetrically about its half-chord axis are calculated by the approximate method. The values obtained are in fair agreement with the results obtained by Lyon's theory and by Cicala's method. Since, in one of the approximations, fewer simplifying assumptions were made than in Cicala's methods, the results should be more accurate. Lack of experimental evidence prevents a definite evaluation of the methods.

Approximate Relations and Charts for Low-Speed Stability Derivatives of Swept Wings. Thomas A. Toll and M. J. Queijo, *U.S., N.A.C.A., Technical Note No. 1581*, May, 1948. 55 pp., figs. 10 references.

Approximate relations for the low-speed stability derivatives of swept wings with dihedral are derived from a simplified theory that takes into account the effects of sweep, aspect ratio, center-of-gravity location, and, in most cases, taper ratio. A comparison of the values of the derivatives obtained from the approximate relations with those values obtained by experiment indicates that the calculated values are fairly reliable over a range of lift coefficients (starting from zero) that decrease as the sweep angle increases. Large discrepancies between calculated and experimental values are found for highly swept wings at the high lift coefficients. This is believed to be caused by a partial separation of the flow from the wing surfaces. A more rigorous method, if based on potential-flow concepts, probably would not provide much improvement in that range of lift coefficients in which partial separation exists. Charts based on the equations and values of the derivatives for unswept wings are given for swept wings having a taper ratio of 1.0.

Damping in Pitch and Roll of Triangular Wings at Supersonic Speeds. Clinton E. Brown and Mac C. Adams. *U.S., N.A.C.A., Technical Note No. 1566*, April, 1948. 29 pp., illus., figs. 8 references.

A method of calculation based on the linearized equations of motion. The wing is represented by a doublet distribution which can be shown to be equivalent to a vortex distribution. The integral equation that is found is solved by analogy with the relations that are known for two-dimensional flow. From the pressure distribution, the damping coefficients in pitch and roll are calculated for a series of wings, the trailing edges of which are cut off so that they lie ahead of the Mach cone arising from their foremost point. The elementary supersonic source solution is used to find the potential function of a line of doublets, and the flows are obtained by the surface distributions of these doublets. The damping derivatives for triangular wings are found to be a function of the ratio of the tangent of the apex angle to the tangent of the ratio of the tangent of the apex angle to the tangent of the Mach angle. As this ratio becomes equal to, and greater than, 1.0 for triangular wings the damping derivatives in pitch and roll

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become constant. The damping derivative in roll becomes equal to one-half the value calculated for an infinite rectangular wing, and the damping derivative in pitch for pitching about the apex becomes equal to 3.375 times that of an infinite rectangular wing.

Test Reports on Three- and Six-Component Measurements on a Series of Tapered Wings of Small Aspect Ratio (Partial Report: Triangular Wing). Lange and Wacke. (*ZWB/UM/1023-5*, September 27, 1943.) *U.S., N.A.C.A., Technical Memorandum No. 1176*, May, 1948. 73 pp., illus., figs.

Aspect ratios were 3, 2, 4/3, and 1. While the flow conditions for the wing, with an aspect ratio of 3, are radically different from those observed with higher aspect ratios, this wing still belongs to the group of wings for which Prandtl's airfoil theory is applicable and marks the lower limit of this class. Three-component measurements showed that the effectiveness of the lift coefficient as a function of the angle of attack, the drag coefficient, and the pitching-moment coefficient decreases with decreasing aspect ratio and increasing sweepback. Photographs of the flow on the wings with aspect ratios 4/3 and 1 showed that in the vicinity of the trailing edge a strong lateral flow toward the wing tips was developed which resulted in an increase in the lift coefficient starting with a value of 0.4. The neutral point for all wings was situated ahead of the moment reference point which was established 3/4 mean chord ahead of the trailing edge. While for the wing with aspect ratio 3 the ratio of the pitching-moment coefficient to the lift coefficient was constant over the entire range of the lift coefficient, for those wings with aspect ratios equal to or less than 2 the neutral point was displaced aft. The maximum lift coefficient increased with decreasing aspect ratio and increasing sweepback. The angle of attack for this maximum remained almost constant. Six-component measurements showed a slight decrease in the lift, drag, and pitching moments with respect to yawed flow only at large angles of attack.

On Airfoil Theory and Experiment. Alan Pope. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 407–410, figs. 6 references.

An examination of the equation for the slope of the lift curve and for the moment coefficient about the aerodynamic center of an airfoil shows that they are both functions of the airfoil thickness. The discrepancy between theory and actual measurements can be attributed to the boundary layer which, on the upper surface, proceeding against an adverse gradient more severe than that on the lower surface, becomes thicker than that of the lower surface and effectively adds S-camber with each angle of attack. Airfoils whose minimum pressure peaks occur well back from the leading edge have steeper lift-curve slopes and more rearward aerodynamic center positions than airfoils with forward pressure peaks. A short approximate method is given which, for airfoils of 9 to 18 per cent thickness ratio, yields the drag "bucket" shape and extent and the value of the drag coefficient within usual engineering limits of accuracy.

An Experimental Analysis of the Forces on Eighteen Aerofoils at High Speeds. W. F. Hilton. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2058*, May, 1946. 57 pp., figs. 16 references. British Information Services, New York. $3.00.

A summary report of tests made in the 1-ft. high-speed tunne to determine the effect of compressibility on the lift and on the moment about the quarter chord of N.A.C.A., R.A.F., Piercy, Clark-Y, and other airfoils. Mach Numbers ranged from 0.3 to 0.85; Reynolds Numbers, from 0.3 to 0.7 millions. Airfoils with a thickness between 6 and 16 obeyed quantitatively the Glauert law. Between 16 and 20 per cent a reduced Glauert effect was noted, while airfoils thicker than 20 per cent exhibited no Glauert effect. The lift results are plotted as a function of both incidence and Mach Number on the same diagram, giving two families (a carpet) of intersecting curves. Data for ten airfoils are compared with compressed air tunnel tests. Observed zero-lift angles were found to agree well with calculations. End effects at the point where the airfoil passes through the tunnel wall, which made the data on drag less reliable than that for lift and moment, was found, in general, to be negligible for airfoils thinner than 10 per cent. Calculated and observed moment coefficients at zero lift were in excellent agreement at low speeds, and variation of the coefficient of moment with angle of attack was characteristically nonlinear for airfoils with maximum thickness at about one-half chord.

Subsonic and Supersonic Tests on a 7½ Per Cent. Bi-Convex Aerofoil. W. F. Hilton. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2196*, May, 1944. 8 pp., figs. 5 references. British Information Services, New York. $0.70.

The airfoil was tested at subsonic Mach Numbers between 0.4 and 0.875 and at supersonic Mach Numbers between 1.25 and 1.46 at incidences from −4° to +4°. While the coefficient of drag at zero incidence, 0.01, is low for this type of section, it increases rapidly with incidence. The moment measurements indicate a change of flow pattern at incidences greater than 1½°, which causes a change in the sign of the moment curve slope. Beyond this incidence the slope of the lift is reduced. The supersonic lifts agree with Ackeret's theory and the moments with Busemann's theory. The observed drags are higher than predicted by theory because of the neglect of skin friction. To obtain an estimate of the maximum lift coefficient, two low-speed lift curves have been plotted up to stalling incidence.

Air Power (43)

The Use of Air Power in 1939–45. Sir Robert Saundby. *The Aeroplane*, Vol. 74, No. 1923, April 16, 1948, pp. 441–443. (Summary of an address.)

Australian Naval Aviation. *Aircraft*, Vol. 26, No. 6, March, 1948, pp. 12–14, 42, illus.

The Elephant, the Whale—and the Eagle. Cy Caldwell. *Aero Digest*, Vol. 56, No. 4, April, 1948, pp. 23–25, 109, 110, map. An analysis of the importance of land-based bombers in global warfare.

Employment and Earnings in Aviation. Ewan Clague. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 26, 27, 110, 112, 113, figs.

A survey based on Department of Labor and A.A.F. statistics, for the period 1939 to 1947 inclusive, of civil and military aircraft production and total employment in prime contracting air-frame, engine, and propeller plants and in subcontracting and parts-supplying plants in the aircraft industry.

Atomic War—Could the United Kingdom Survive It? Norman Macmillan. *Aeronautics*, Vol. 18, No. 6, May, 1948, pp. 22–25. 3 references.

Airplane Design & Description (10)

Cargo Plane Design. John H. Frederick. *Distribution Age*, Vol. 47, No. 4, April, 1948, pp. 38, 39, 54, 55, illus.

Development of the air-cargo traffic potential awaits the development and production of an airplane expressly designed to provide efficient loading, handling, stowage, and transportation of commodities. Despite the rapid decrease of direct operating costs per cargo unit with increased aircraft weight and capacity, a cargo design would probably specify an airplane of moderate size. This would be because of the decreased economy in operation and maintenance of aircraft with more than eight engines, the restriction of airport runways and facilities, the optimum ratio between flying time and loading time, the need for adaptability to other types of operation, and the economical fuel-pay-load ratio under predictable speed and range requirements.

Design and Airworthiness Requirements. Walter Tye. *The Aeroplane*, Vol. 74, No. 1924, April 23, 1948, 479–481, illus. (Extended summary of a paper.) A survey of the trends in aircraft design which are directly attributable to airworthiness requirements.

Data for Odd-Shaped Tanks. Curtis L. Bates. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 68, 69, 80, figs.

A method employing graphical integration which can be simplified to a simple tabular process. The area of any section between two chordwise stations is determined by plotting the height against the chord distance and solving the integral by the equivalent trapezoid method. From a plot of the moment of area against the chord distance, the moment of area and the center of gravity for a specified area can be obtained. By a similar procedure these values are related to a spanwise dimension, and volume and center of gravity can be determined for integral wing tanks.

Nonmetallic Fuel Tanks are Favored for Aircraft. John E. Lindberg, Frank R. Zerilli, and C. R. Ursell. *S.A.E. Journal*, Vol. 56, No. 4, April, 1948, pp. 34–39, figs. (Extended summary of a paper.)

An evaluation of the service performance of the adhesive-membrane and the caulked-joint integral fuel tank and the bladder-cell fuel tank. It is impossible with present experience to judge whether the bladder-cell tank will give sufficient relief from

the difficulties encountered in the sealing and maintaining of integral tanks to offset its greater weight and lower fuel capacity.

Toward Simpler Cockpits. Roy Cross. *Aeronautics*, Vol. 18, No. 6, May, 1948, pp. 32–25, illus.

The U.S. Navy Bureau of Aeronautics' functional cockpit, which has been incorporated in the Fairchild XNQ-1 and the North American XSN2J-1, is not only a standard that can simplify pilot training and minimize the difficulty of changing from one type of aircraft to another, but it represents the progress that has been made in designing cockpits to minimize pilot error. Like controls have been grouped together and have been positioned logically with reference to the item they control. Controls that are used continually are placed where their manipulation will cause the least fatigue. They have been given distinctive shape for rapid identification, and their motion is in the most readily apprehended sense. Research is in progress to develop indicating instruments that can be read with maximum accuracy in the least time and will eliminate the maze of dials the pilot is now required to read. Another trend in control design is the development of automatic controls and warning signals and single-lever actuation of control sequences.

Northrop B-35 Landing Gear. C. J. Dunn. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 59, 60, 116–118, diagrs. The design and performance of the landing gear, the main and auxiliary steering and braking control systems, the retraction system, and the electrical actuator units.

Castering Gear for Transports. Alexander McSurely. *Aviation Week*, Vol. 48, No. 16, April 26, 1948, p. 16, figs. Demonstration of the All-American castering device on a Beechcraft Model 18 and of the Goodyear castering gear on a DC-3.

Air Progress; Development of Fuselages. Douglas Rolfe. *Air Trails Pictorial*, Vol. 30, No. 3, June, 1948, pp. 37, 38, cutaway drawings. Details of construction of early fuselage designs.

An Ace in the Hole; Some News and Views on Naval Jet Fighters. A. Marthason. *The Aeroplane*, Vol. 74, No. 1925, April 30, 1948, pp. 506, 507, illus.

Chronicles of Jet Propulsion. IX—United Kingdom (Continued). *The Aeroplane Spotter*, Vol. 9, No. 212, May 1, 1948, p. 106, illus.

Freighter Aircraft. II. H. W. Ainsley. *Airport & Air Transportation*, Vol. 2 (N.S.), No. 59, April, 1948, pp. 381, 382, illus.

A brief survey of British cargo-aircraft design. Includes the Miles Aerovan, Merchantman, and M.68; the Bristol Freighter; and the Handley Page Freighter. The Universal Freighter proposed by General Aircraft—a high-wing four-engined monoplane with tricycle landing gear, a cargo capacity of 5,760 cu.ft., and an uninterrupted main compartment 36 by 10 by 10 ft.—will be designed to carry a load of 8 tons over 1,000 miles. Its loading and stowage features and its operational characteristics are designed expressly for freight service.

Eight Czechs. *Flying*, Vol. 42, No. 5, May, 1948, pp. 22, 23, illus. Illustrations and specifications of eight Czechoslovakian personal airplanes.

New Shapes in the Air: The Avro 701 Athena T. MK. 1 and the Grumman XF9F-2 Panther. *The Aeroplane Spotter*, Vol. 9, No. 212, May 1, 1948, p. 101, illus., diagrs.

Lightweight Transport Readied for Testing (Aero Design & Engineering Corp. Aero Commander 2-Engined Transport). *Aviation Week*, Vol. 48, No. 16, April 26, 1948, p. 41, illus.

First Turboprop Trainer (Avro Athena Mk. I.) Nears Completion. Roy Cross. *Aviation Week*, Vol. 48, No. 17, May 3, 1948, pp. 21, 22, 24, 26, illus.

Boeing's Team of the Air. *Aero Digest*, Vol. 56, No. 4, April, 1948, pp. 68, 69, illus.

The standardization of bomber and transport aircraft and the adaptation of these standard craft to commercial cargo and passenger transport is exemplified by the Boeing B-50 and the YC-97, both of which have identical wings, tails, landing gear, and interchangable major assemblies. This practice results in more economical production, swifter development, reduced parts stocks, and more personnel better trained in repair and maintenance.

Brigand Bomber (Bristol B.1). *Flight*, Vol. 53, No. 2053, April 29, 1948, p. 467, illus.

Canadair. Albert Turner. *Aircraft and Airport*, Vol. 10, No. 4, April, 1948, pp. 14–16, 18, 20, illus. Includes description of the pressurized C-4F2 cargo airplane.

Airfoil Fuselage (Cancargo Burnelli Loadmaster Transport); More Lift and Cargo? *Aviation Week*, Vol. 48, No. 16, April 26, 1948, p. 28, illus.

The Cessna 170. Leighton Collins. *Air Facts*, Vol. 11, No. 5, May 1, 1948, pp. 22–30, illus.

Ace in the Air; First Impressions of the (Chrislea) Series II Super Ace; Novel Wheel Control and Accelerator Pedal. Maurice A. Smith. *Flight*, Vol. 53, No. 2052, April 22, 1948, pp. 446–448, illus., diagr.

Take-off and landing techniques, and handling characteristics. The control column projects horizontally from the panel. Vertical motion of the column controls the elevators, while horizontal movement controls the rudder. Rotation of the control wheel on the head of the column governs the ailerons.

Flying the (Chrislea Series II) Super Ace. R. G. Worcester. *The Aeroplane*, Vol. 74, No. 1924, April 23, 1948, pp. 476–478, illus., figs.

Competition From England. *Aviation Week*, Vol. 48, No. 17, May 3, 1948, pp. 35, 36, figs. The Chrislea Super Ace 145-hp. four-place airplane.

Two of the Biggest by Convair: The Convair B-36 and the Convair XC-99. *The Aeroplane*, Vol. 74, No. 1924, April 23, 1948, p. 474, illus., diagrs.

Custer Channel Wing. John Forney Rudy. *Air Trails Pictorial*, Vol. 30, No. 3, June, 1948, pp. 22, 23, 83, 84, illus.

Dragon's Descendant (de Havilland Drover D.H.A.-3). *Flight*, Vol. 53, No. 2053, April 29, 1948, p. 462, illus., diagr.

The Drover Under Test (de Havilland 2-Engined Transport), *Aircraft*, Vol. 26, No. 6, March, 1948, p. 15, illus.

Some (de Havilland) Drover Impressions. *Aircraft*, Vol. 26, No. 7, April, 1948, pp. 16, 17, 46, illus., figs.

Meteor's Stable-Mate; An Exposé of the Nene-Powered Gloster E.1/44. *Flight*, Vol. 53, No. 2052, April 22, 1948, pp. 429–432, cutaway drawings.

Flying the Goodyear Duck (GA-2 Amphibian). R. G. Worcester. *The Airplane*, Vol. 74, No. 1925, April 30, 1948, pp. 502, 503, illus.

P-80 Development. *Plane Facts*, Vol. 5, No. 3, March, 1948, pp. 8–11, 28–30, illus. 1 reference.

A résumé of the structural features, air ducting, and fuel systems that were developed during the design of the Lockheed P-80. Includes notes of compressibility, flutter, and vibration effects and performance and control characteristics.

The Piper Vagabond (PA-15). Leighton Collins. *Air Facts*, Vol. 11, No. 5, May 1, 1948, pp. 46–62, illus.

Development of the PA-15 (Piper Vagabond). Howard Piper. *Air Facts*, Vol. 11, No. 5, May 1, 1948, pp. 63–68.

A New Ship-Plane Formula; Preliminary Details of One of the First Post-War French Military Aircraft to Be Completed, the Société Nationale de Constructions d'Aéronautiques du Centre NC-1070. *Aircraft Engineering*, Vol. 20, No. 230, April, 1948, pp. 114, 115, illus.

Airports & Airways (39)

Stop Airport Fires. George H. Tryon. *Aviation Maintenance & Operations*, Vol. 9, No. 5, April, 1948, pp. 26–29, 74, 76, 78, 80, illus.

A discussion of the fire-protection features and the fire-prevention facilities that should be available at an airport. Units such as fuel-storage tanks, fuel pumps, engines, boilers, and blowers should be isolated in separate buildings. The layout, dispersal, and construction of hangars and buildings should be appropriate to the type of aircraft they accommodate and the kind of work performed. Automatic detection systems and sprinkler systems should incorporate adequate means of spreading the fire alarm. The number of extinguishers and extinguisher carts should be appropriate to the size of the installation. The major airport fires during 1947 are listed giving location, property involved, and estimated loss. The minimum rescue equipment is tabulated for various types of airports.

Tarmac Control. *Flight*, Vol. 53, No. 2050, April 8, 1948, pp. 390, 391, illus.

Marshalling systems used to control the spotting of aircraft at the proper bay and the movement of passengers to and from the aircraft. Neither of the airports discussed, London and Northolt, have permanent bays or covered passenger gangways for loading and off loading.

Canadian Aviation's Annual Airport Directory. *Canadian Aviation*, Vol. 21, No. 5, May, 1948, pp. 39–44, 46, 48, 50, 61, 62.

Airport Test Case. John C. Ross. *Flying*, Vol. 42, No. 5, May, 1948, pp. 30, 31, 73, 74, illus.

Summary of the legal decisions and an estimate of their importance as air-law precedents in the case concerning the construction of an airport adjacent to an Akron, Ohio, residential district.

Airports of the World: Gatwick, A Modern Charter Terminal. *Airports & Air Transportation*, Vol. 2, No. 59, April, 1948, pp. 384–387, illus., map.

Turf Topics. I. George W. Milnes. *Aviation Maintenance & Operations*, Vol. 9, No. 5, April, 1948, p. 41.

Design of Japanese Structures. U. S. Naval Technical Mission to Japan. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1154*, January, 1946. 49 pp., figs. British Information Services, New York. $1.45.

The water-front structures and facilities of Japanese ship yards, aircraft hangar design, and wartime construction regulations. At Kisarazu Airfield, hangars were of twin two-hinged arch construction, which served to reduce the amount of steel over single two-hinged construction.

New B.O.A.C. Marine Terminal at Southampton. *Modern Transport*, Vol. 59, No. 1517, April 24, 1948, pp. 5, 14, illus.

B.O.A.C. Flying-Boat Terminal. *The Engineer*, Vol. 185, No. 4813, April 23, 1948, pp. 407, 408, illus.

New Development Increases Utility of the Seaplane. *Plane Facts*, Vol. 5, No. 3, March, 1948, pp. 17, 30, illus.

An inflatable rubberized fabric emergency dock with plywood decking has been designed by the Navy Bureau of Aeronautics and the Goodyear Company. The dock is constructed from nine nylon-coated fabric pontoons each 25 ft. long and 7 ft. wide. It is light enough to be transported by air.

Visual Aids For Low Visibility Conditions. E. S. Calvert. *Flight*, Vol. 53, No. 2052, April 22, 1948, pp. 450, 451. (Extended summary of a paper.)

The use of day marking lights can increase the distance at which the runway can be picked up, assist the pilot in making judgments of height by accentuating the perspective angle and texture of the surface, and provide accurate guides when close to the ground or taxiing. Systems of parallel lines depend on a vanishing point to provide the pilot with a directional reference and on changes in the perspective angle to indicate height and lateral displacement. Under poor visibility conditions better reference could be obtained by a single line of lights intersected at intervals by cross bars of equal length.

Leading Lights; Demonstration of New Approach Lighting System Installed at Farnborough. *Flight*, Vol. 53, No. 2053, April 29, 1948, pp. 457–459, illus., figs.

Progress in Landing Aids at Arcata. A. L. Lewis. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 40, 41, 118, 120, illus., figs.

Ground Lighting for Civil Flying. H. J. Turner. *Airports and Transportation*, Vol. 2 (N.S.), No. 59, April, 1948, pp. 367–373, figs.

A summary of the recommendations of the British Standards Institution for the layout and design of civil airport lighting equipment. Includes beacons, approach lights, angle of approach lights, threshold and contact lights, and runway area floodlights.

Horizon Bar Approach Lighting System. *The Engineer*, Vol. 185, No. 4814, April 30, 1948, pp. 420, 421, diagrs.

The advantages of the horizon bar airport approach lighting system were demonstrated before its actual installation at the airfield at Farnsborough by the cyclorama. This apparatus simulates the changes in the field of vision of a pilot as he controls his airplane during a landing. During 8,000 tests under all types of simulated visibility conditions the horizon bar lighting pattern was preferred because the six successive cross bars not only gave a recurrent horizon substitute but, because of the toe-in in their length, served as a reference for the correct glide angle.

The Cross-Bar Night Landing System. *The Aeroplane*, Vol. 74, No. 1925, April 30, 1948, pp. 497, 498, illus.

The Farnborough cross-bar airfield approach lighting system consists of a single line of runway marker lights intersected by six perpendicular cross bars spaced 600 ft. apart. The width of the cross bars is toed in to give the illusion of equal width when the aircraft is descending at a 2.5° angle of approach. These bars provide the pilot with six successive simulated horizons by which he can maintain lateral orientation. Variation in the number of marker lights placed between the cross bars indicate his range.

Lights Out. Leslie C. Vipond. *Aviation Maintenance & Operations*, Vol. 9, No. 5, April, 1948, pp. 34, 35, 92, 94, 96, illus.

Directions for using a megger to test an underground series airport lighting circuit for deteriorated insulation and grounds. The method provides a quantitative reading of the insulation characteristics of the cable and permits defects to be recognized before failure of the system.

Aviation Medicine (19)

Negative Acceleration. Robert S. Shaw. *The Military Surgeon*, Vol. 102, No. 6, June, 1948, pp. 483–487, figs. 6 references.

A summary of the pathology of vascular, visceral, and skeletal injury caused by negative acceleration. Accurate data are insufficient to obtain more than an approximate curve to represent the variation with time of human tolerance to exposure to negative acceleration. A safe value for a $^1/_{100}$ of a second has been set at 20*g*, but crash survival data suggest that much higher values can be tolerated for extremely small periods of time. Investigation conducted in the long-time low *g*-range indicates that some protection may be offered by the prone position and the avoidance of any maneuver such as straining, holding the breath, or yelling. Closing the glottis and attempting inspiration result in some reduction in the pressure in the veins of the head and afford considerable subjective relief.

U.S.A.F. Developments in the Selection and Classification of Flyers. Harry G. Armstrong. *The Military Surgeon*, Vol. 102, No. 6, June, 1948, pp. 469–473, figs.

An evaluation of the saving in time, instructors, and money effected by the psychological classification program used by the U.S. Air Force to screen applicants for flight training.

Comfortization (23)

Controlling Temperature in Jet Aircraft. D. O. Moeller and O. A. Sanne. *Aviation Week*, Vol. 48, No. 16, April 19, 1948, pp. 26, 29, 30–32, figs.

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FLIGHT RESEARCH INSTRUMENTATION

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Since pressurization makes it necessary to supply the cabin ventilation system with air bled from the compressor of jet power plants, high speeds and altitudes impose a considerable load on the aircraft refrigeration system. Two systems that use air at ram temperature as the cooling medium have been developed which appear to meet requirements. The simple air-cycle system consists of a heat exchanger, expansion turbine, and a cooling air fan. The bootstrap system uses two heat exchangers combined with a centrifugal compressor and an expansion turbine. The compressor raises the pressure of the air cooled in the first exchanger. It is cooled again in the second exchanger and the turbine. The turbine drives the compressor.

Stratocruiser's Air Conditioning System. R. L. Linforth. *S.A.E. Journal*, Vol. 56, No. 5, May, 1948, pp. 19–23, fig., diagr. (Extended summary of a paper.) (Cf. AER 4/48:51.)

Fluid Drive for Supercharger. *Aircraft and Airport*, Vol. 10, No. 4, April, 1948, p. 39, fig.

The Stratos Corporation supercharger delivers 65 lbs. of air per min. to the aircraft cabin at 8,000 ft. altitude. It weighs 53 lbs. dry. The primary compressor incorporates a hydraulic coupling that varies the speed of the impeller according to the oil level with the coupling.

External Sound Levels of Aircraft. R. L. Field, T. M. Edwards, Pell Kangas, and G. L. Pigman. *Aeronautical Engineering Review*, Vol. 7, No. 7, July, 1948, pp. 42–49, 51, figs. 2 references.

The sound levels at various distances from cruising, climbing, and aircraft taking off were measured under controlled conditions with six aircraft powered by engines of 65 to 2,400 hp. each. Additional measurements were made for miscellaneous, private, commercial, and military aircraft in general airport traffic. Similar measurements were made of highway truck and passenger-car traffic and freight and passenger railway trains. The aircraft models tested produced sound intensity levels ranging from 78 to 103 decibels at a distance of 500 ft. during take-off. During flight this level decreased about 6.5 to 8.5 decibels for each doubling of distance from the airplane.

Seats to Suit; A New Power-Operated Bed Seat: Lightweight Folding Designs (Christie-Tyler, Ltd.). *Flight*, Vol. 53, No. 2053, April 29, 1948, p. 475, illus.

Electronics (3)

Problems in Theory and Technique of Antennas. I. R. Appel, H. Schlicke, and H. Rindfleisch. (*ZWB/ VIFS/E-1*, March, 1943.) *U.S., Air Force, Translation No. F-TS-2222-RE*, November, 1947. 232 pp., diagrs., figs. 12 references.

A collection of 19 papers: General Requirements of the Army on the Qualities and Dimensions of Movable and Fixed Antennas, R. Appel. Ship Transmission Antenna Installations With Non-Grounded Antenna Part and Requirements of the Navy as to Shipboard Antenna Installations, H. Schlicke. Directional Antenna Systems With Antenna Amplifiers, H. Rindfleisch. Requirements of the Airforce of dm. Antennas for Directional Connections, H. Dahlmann. Aircraft Antennas, H. Netherler. Surface Excitation, S. Zisler. Ultra Short Wave Aircraft Antennas, W. Kloepfer. Long Wire Antennas on Airplane Wings, G. Goubau. Antenna and Range, K. Franez. Principles of Directional Antennas, W. Moser. New Ultra Short Wave Directional Antenna With Purely Vertical Polarization, R. M. Wundt. A Directional Antenna System for dm- and cm- Waves Without Energy Cable to the Instrument, K. Laemmchen. Ground Direction-Finding Antenna Systems, W. Hasselbeck. Direction Finding Loop With Iron Core, A. Weis. On Multiple Utilization of Transmitter Antennas, H. Brueckmann. On Anti-Fading Antennas, H. Brueckmann. Antennas on Railroad Cars, A. Kraus. Raw Material Problems With Antennas From the Point of View of Radio Engineering, W. Hahn. Direction for the Uniform Designation of Antenna Magnitudes in Lectures and Reports, Four-Year-Plan Institute for Oscillation Research.

The Plessey Microwave Multi-Channel Radio Communication System. *Airports & Air Transportation*, Vol. 2, No. 59, April, 1948, pp. 388–390, illus.

The design and operation of the Plessey microwave telecommunications system. Eight duplex channels make possible the simultaneous transmission of eight mixed speech and multiple telegraph circuits over a microwave radio beam for distances up to about 60 miles.

Factors Affecting the Frequency Deviation in Reactance Tube Frequency Modulation Circuits. Chai Yeh and Y. K. Tz'u. *Chinese Journal of Physics*, Vol. 7, No. 2, December, 1947, pp. 72–80, figs. 12 references.

Bibliography on Transductors, Magnetic Amplifiers, Etc. H. B. Fox. *Instruments*, Vol. 21, No. 4, April, 1948, pp. 332, 352, 354, 356, 358, 360, 362. 213 references to U.S. Patents and American and foreign periodical articles.

An Investigation of Radio-Frequency Radiation From the Sun. M. Ryle and D. D. Vonberg. *Royal Society of London, Proceedings*, Vol. 193, No. 1032, April 22, 1948, pp. 98–120, figs. 16 references.

A Possible Mode of Propagation of the "Slow" or Tail Component in Atmospherics. A. L. Hales. *Royal Society of London, Proceedings*, Vol. 193, No. 1032, April 22, 1948, pp. 60–71, figs. 7 references.

Solar Radiation in the Radio Spectrum. I—Radiation From the Quiet Sun. D. F. Martyn. *Royal Society of London, Proceedings*, Vol. 193, No. 1032, April 22, 1948, pp. 44–59, figs. 33 references.

Microwave Frequency Standards. B. F. Husten and Harold Lyons. *Electrical Engineering*, Vol. 67, No. 5, May, 1948, pp. 436–439, illus., figs. 1 reference.

Block diagrams of the National Bureau of Standards microwave frequency standard giving spot frequency coverage and the standard with adjustable oscillators giving continuous coverage between 300 and 30,000 megacycles. The standard microwave frequencies are obtained from the National 100 kc. primary standard by using a system of frequency multiplication, frequency conversion, and harmonic selection. The accuracy of the system is one part in 10 million.

All-Weather Airway: 15-Year Job. Robert Hotz. *Aviation Week*, Vol. 48, No. 16, April 26, 1948, pp. 23, 24, fig.

Summary of the target proposal of the Radio Technical Commission for Aeronautics for a system of all-weather electronic airways with notes on costs, administration, and equipment. The traffic-control and the navigation units are the air-borne equipment. The ground equipment includes: traffic-data relay, flow control, and airspace-separation equipment; automatic air-traffic control, flight-path planning, airport-time utilization, nav-aid, and landing-aid installations; a detail flow-control display; and a general planning display. A table lists the various transitional equipment called for by the interim program and the equipment specified in the target plan and indicates for each item its expected period of development; the length of time to be allowed for tests, production, and installation; and the date of obsolescence of the transitional equipment.

They Call It "Tricon." *Aero Digest*, Vol. 56, No. 4, April, 1948, pp. 42–45, 102, diagrs.

A detailed description of the function and principles of operation of TRIple COincidence Navigation. A master and two slave ground transmitters emit pulse signals simultaneously. The duration of the master pulse is longer than the other two and the initial master pulse is a characteristic signal. A cyclic variation of triple coincidences is used to fix the location of a selected number of discrete points along the airway to be navigated. A rudimentary airway is developed for purposes of explanation. It consists of two lanes of traffic running in one direction, a barrier lane, and two lanes of opposing traffic. Two-mile spacing is established between the parallel tracks and the successive fix points on each track are set at half-mile intervals. By measuring the incremental differences in transmission time of the two short pulses at the point at which triple coincidence is observed, it is possible to determine the lateral deviation of the aircraft from the track. Traffic control is performed by pulse communication channels that are activated by the same triple coincidences providing navigation information. Air-air transmission gives safety information, air-ground communication gives the ground controllers a complete picture of the air traffic, and ground-air transmission allows traffic control procedures to be put into effect.

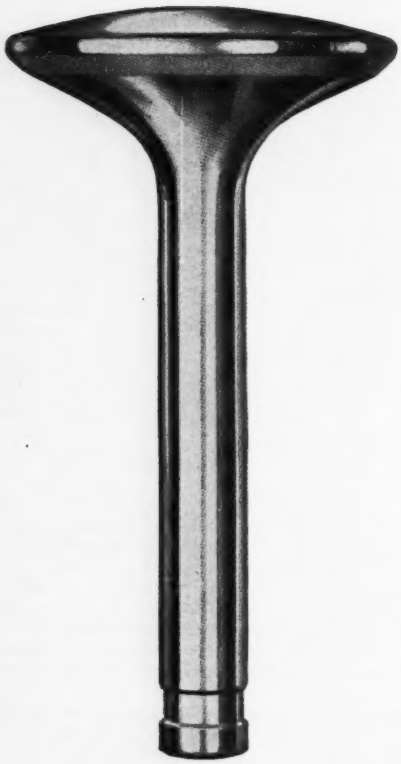
They Call It "Tricon." II—Operational Considerations. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 64–67, 113, 114, 116, diagrs.

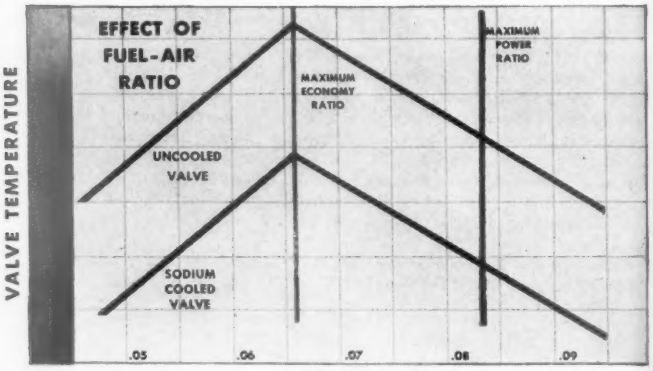
A proposed air-borne display for the information required to navigate on one of the airways set up by the triple coincidence air-navigation system and possible methods of presenting the information to the controller at the ground station. The operation of the system and its advantages, both to the scheduled air-line pilot and to the private flier, are examined in detail. The advantages of this rigid locating system are compared with that proposed by the Radio Technical Commission for Aeronautics, which

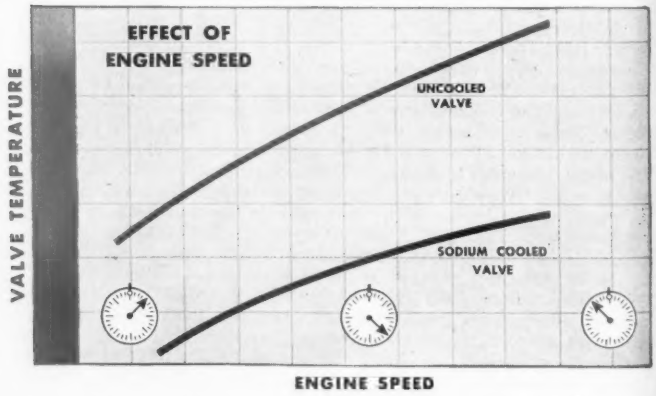
Why Sodium Cooled Valves?

The trend of modern engines is to operate at higher speed and more economical fuel-air ratio. In considering factors which influence exhaust valve life, temperature is the dominant one. High temperatures sharply reduce the resistance to corrosion, distortion, and fatigue life of the finest alloy steel. The effectiveness of sodium cooling in reducing valve temperatures is shown by the curves below, which are typical of recorded test data.

The curve "Effect of Fuel-Air Ratio" shows that as the mixture is leaned out to obtain maximum economy, valve temperatures rise. The curve showing "Effect of Engine Speed" indicates that temperature rises quite rapidly as speed increases.







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proposes an infinite number of paths from which the pilot would make his choice either prior to or during flight.

The Air Force Flies the Weather. Nathaniel F. Silsbee and Ralph W. Brown. *Aero Digest*, Vol. 56, No. 4, April, 1948, pp. 37, 38, 80, 81, illus. Summary of the radar and automatic control testing and development conducted by the All-Weather Flying Division at Clinton County Air Field, Ohio.

Australian Approach to Short Range Aids. J. H. Frewen. *The Log*, Vol. 8, No. 4, April, 1948, pp. 80–83, figs.

Brief description of the Distance Measuring Equipment and Multi-Track Range under development by the Council of Scientific and Industrial Research for short-range navigation aid and traffic control. The automatic system is designed to allow the controller to give each aircraft an orbiting distance and to stack all incoming aircraft horizontally at suitable intervals.

Australians Developing Multiple Track Radar. *Canadian Aviation*, Vol. 21, No. 5, May, 1948, p. 70, fig.

Maintenance Communications Set. W. C. Milligan. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 49, 110, diagr.

A portable two-station system that permits communication between personnel several hundred feet apart. Amplification is provided without the use of electronic tubes by using push-pull audio output transformers in reverse to their normal operation. Current drain from a 6-volt battery is 50–100 milliamp.

The Preparation of NBS Casting Resin. M. Weinberg. *U.S., National Bureau of Standards, Technical Report No. 1149*, October 16, 1947. 3 pp.

The Chemistry of Styrene Resins. Frank W. Rinehart. *U.S., National Bureau of Standards, Technical Report No. 1162*, October 16, 1947. 15 pp. 12 references.

Application and Performance of the NBS Casting Resin. P. J. Franklin. *U.S., National Bureau of Standards, Technical Report No. 1148*, October 16, 1947. 14 pp.

The Absolute Calibration of Electro-Mechanical Pickups. H. M. Trent. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 49–52. 7 references.

Given two linear indicators, one of which is bilateral, it is shown that the sensitivities of the units can be established in both magnitude and phase by three experiments that do not involve the direct measurement of oscillating mechanical quantities. The theory of the method is based upon the reciprocity theorem, and, since this theorem does not involve the internal constants of any network, the technique is applicable to every electromechanical pickup regardless of its design.

Shielding Principle Provides Electrical Micrometer. *Instruments*, Vol. 21, No. 4, April, 1948, pp. 294, 296, illus.

A radiating coil is fed a high-frequency current that induces a voltage in a secondary coil. When the coil assembly is in the vicinity of a metallic object, the screening effect of the object causes a change in the induced voltage which is proportional to the distance between the pickup coil and the object. Micrometer readings from zero to 0.02 in. can be read with an accuracy of 0.0001 in.

Circuit for Condenser Microphones With Low Noise Level. J. J. Zaalberg. *Phillips Technical Review*, Vol. 9, No. 12, 1947/1948, pp. 357–363, illus., figs.

When a condenser-microphone is used in series with a direct voltage source and a resistor or when it forms part of the high-frequency oscillating circuit of an oscillator, it is impossible to connect the microphone directly to a cable and retain a high sensitivity and low signal-to-noise ratio. In both cases either an amplifier or an oscillator stage must be set up close to the microphone. These difficulties can be avoided if the microphone is incorporated in a bridge circuit which, as the diaphragm vibrates, produces an amplitude-modulated high-frequency voltage. The microphone with the built-in bridge circuit can be connected directly to a cable leading to an amplifier and a detector stage. The method can be used for other capacitive vibration pickups.

The Method of High-Speed Mechanical Switching Applied to Multiple Oscillograph Measurements and Its Adaptation for Measurements in Flight. D. H. Peirson. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2231*, April, 1945. 20 pp., illus., diagrs., figs. British Information Services, New York. $1.45.

A four-way switch rotating at 100 times per sec. is used to feed, in sequence, four independent signals to a conventional cathode-ray oscilloscope. After several cycles of switching each signal appears as a dotted trace on the screen. In order to avoid superposition of the traces, continuously variable voltages, independent of each other and of the signal voltages, are applied to the separate traces before switching. The individual Y-shift control thus obtained permits the traces to be spaced over the face of the tube. This technique has been used in various aircraft to measure resistance strain-gage signals in flight. Ground and airborne measurements have been made of amplitudes of 10^{-4} volts and larger, over a frequency range from 0 to 20 cycles per sec.

A Circuit For Compensating Hot Wires Used in the Measurement of Turbulence. R. W. F. Gould. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2240*, August, 1945. 7 pp., figs. 3 references. British Information Services, New York. $0.55.

The fluctuations of potential which are developed across a hot-wire anemometer used for measuring turbulence must be corrected both for amplitude and for phase to compensate for the failure of the wire to respond equally to fluctuations of all frequencies. A compact circuit is outlined which requires no large inductance and has a high input impedance that produces negligible damping to the previous stage. The circuit is similar to the conventional phase-splitting circuit used for feeding a push-pull stage from a single stage. The cathode load resistance, however, is partially by-passed by a condenser at high frequencies. When an alternating potential is applied between the grid and the ground, the effective potential applied to the tube is smaller than the input signal because of the feedback voltage generated across the network between the cathode and the ground. This feedback voltage is greater at low frequencies. Thus the gain of the stage will rise with frequency, and the frequency characteristics of this amplifier stage may be made to conform to the compensation requirements of the hot wire.

Airborne Magnetometer Survey. D. N. Kendall. *Flight*, Vol. 53, No. 2053, April 29, 1948, pp. 472, 473, diagrs., figs. (Summary of a paper.)

The magnetic air detector records the small local variations in the earth's magnetic field as a continuous profile. It is towed sufficiently far behind an airplane to be free of the airplane's magnetic field. The instrument automatically compensates for wandering of the recording coil, and its records permit a reading to within one gamma. The comparison of profiles taken at two different altitudes enable the size and depth of an underground body to be calculated with reasonable certainty.

Engineering Practices & Aids (49)

A Study of Patent Policies in Educational Institutions, Giving Specific Attention to the Massachusetts Institute of Technology. II. Vincent Lee McKusick. *Franklin Institute, Journal*, Vol. 245, No. 4, April, 1948, pp. 272–300, figs. 47 references.

Equipment

ELECTRICAL (16)

Performance of Electrical and Radio Equipment at 40,000 Feet. Karl Martinez. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting, New York*, April 13–15, 1948. 14 pp., figs. 1 reference.

Test flights at altitudes above 40,000, in addition to providing information on the behavior of specific electric equipment, were used to obtain data on the temperature and humidity which later would assist in the laboratory simulation of extreme altitude conditions. During the test flight this environment had a marked effect on the resistance of the aircraft wiring system and caused the erratic operation of limit-switch plungers by contracting the plunger sleeves beyond their allowable tolerance. Electric drives in the control system were overloaded when the low-temperature limit of the lubricant in the system was exceeded. In spite of temperatures in the vicinity of −75°F. the cooling of rotating electrical equipment presented a problem because of the low density of the air. The solution lay in the incorporation of good heat exchange characteristics in the design of the unit, the use of ducting to take advantage of pressure differentials in the vicinity, and in some cases the use of refrigeration. Brush wear was excessive even for those brushes that have a reasonable life at 25,000 ft. Many electrical plugs were found to arc along the surface of the insulator between the pins and between the pins and the shell, indicating the need for respacing the pins and the use of an insulator having a high surface voltage breakdown. The arc rupturing characteristics of various switches showed the need for switch

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housings and insulating materials that will not vaporize when heated by the arc and leave an insulating film on the contacts after the arc has been extinguished.

HYDRAULIC & PNEUMATIC (20)

An Hydraulic Wing-Folding System. *The Aeroplane*, Vol. 74, No. 1923, April 16, 1948, pp. 446, 447, illus., cutaway drawings.

The design and construction of the wing-folding mechanism used in the Supermarine Seafire 47. Includes: operating sequence; safety devices, locks, and indicator; layout of cockpit controls; and power transmission lines through hinge.

Step-By-Step Outline for Inspecting and Adjusting Hydraulic Brakes. *Aviation Maintenance & Operations*, Vol. 9, No. 5, April, 1948, pp. 37–40, illus.

Flight Safety & Rescue (15)

Loss Prevention Programs in Civil Aviation. Jerome Lederer. *Aeronautical Engineering Review*, Vol. 7, No. 7, July, 1948, pp. 25–32, figs.

An inquiry into the present status of safety in commercial and private air transportation and the yardsticks by which it is measured. Regardless of the basis on which a statistical survey is made, it should be interpreted by comparison with the ordinary hazards of living and the public's concept of an acceptable degree or magnitude of safety. Statistics for personal flying are inadequate, but they show it does not come up to the accepted standard of safe transportation. Scheduled air lines, however, have a record comparable with that of other means of transportation. Safety and loss prevention programs have been undertaken by governmental agencies, research institutions, and private industry. These education and enforcement programs have been primarily directed to the aircraft operator and the pilot. The engineer who, because of his basic work on aircraft design, is an important factor should also be the object of similar educational programs.

What of Air Safety? Robin Beach. *Electrical Engineering*, Vol. 67, No. 5, May, 1948, pp. 423–429, illus. 3 references.

The rotation of the propellers of an airplane generates electrostatic charges, which, if discharged uncontrolled to the atmosphere, will set up high-frequency oscillations on the blades and constitute a serious source of radio interference and error in the navigation instruments. If the charge discharges to the air frame through the crankshaft and engine housing, it can cause pitting of the propeller, pitting of the crankshaft and bearings, and crankcase explosions. Tufts of sharp-pointed multiple-bristle stainless-steel electrostatic ionizers, if affixed to the propeller blades, will control atmospheric discharge and eliminate the cause of high-frequency oscillations by keeping the potential at the threshold value for ionization. Ionizers of this type have sufficient durability to withstand the erosion to which they are subjected. Residual electrostatic currents can by-pass the engine either through the ground brushes on one of the sliprings in pitch-changing propellers or through a special wiper system. The electrostatic charge that is built up on the aircraft itself during flight can also constitute a serious radio and fire hazard by discharging between parts of differing potential. An adequate installation of multiple-bristle ionizers on the trailing edges of the wings and empennage can dissipate the charge and also remove one source of tire failure caused by discharge to the earth upon landing. The prevention of baggage-compartment fires caused by sparking of the static charge on the baggage can be accomplished only by proper ventilation to remove inflammable vapors.

Steps to Aircraft Accident Prevention. S. Jailler. *Aero Digest*, Vol. 56, No. 4, April, 1948, pp. 48, 49, 112, 113, illus.

To reduce the number of decisions and actions that a pilot of a multiengined aircraft is called upon to make in an emergency, the responsibilities of the flight crew should be reallocated. The pilot should man the aerodynamic controls, while all engine and undercarriage controls should be the sole responsibility of the engineer.

Aircraft Fire Protection. David H. Moore, Jr. *Aero Digest*, Vol. 56, No. 4, April, 1948, pp. 70, 72, 74, 76, 110–112, diagrs. 8 references.

A survey of American fire detector, warning, and extinguisher systems, and a description of current British practice. These developments are compared with similar progress made in Germany, Japan, and Italy.

The "Star Tiger" Inquiry. I. *The Aeroplane*, Vol. 74, No. 1924, April 23, 1948, pp. 482, 483, illus.

Summary of the testimony heard at the Judicial Inquiry convened on April 12, 1948, to inquire into the loss of the Tudor IV of the B.S.A.A. enroute from the Azores to Bermuda.

Flight Testing (13)

Three Rules to Guide Test Pilots. Lawrence A. Clousing. *Aviation Week*, Vol. 48, No. 19, May 10, 1948, pp. 20–22, 24, illus.

When an aircraft is being tested at high subsonic speeds, inadvertent pitching and stalling may occur. At certain Mach Numbers and load factors buffeting sets in, and, as the speed increases, the control characteristics of the airplane may undergo a radical change with or without preliminary warning to the pilot. In order to ensure maximum safety for both the test pilot and the aircraft, the N.A.C.A., as a matter of policy, conducts initial tests at an altitude at which excessive air loads cannot result even though the airplane is stalled. Once the local velocities on the wing exceed the local speed of sound, the flight tests at progressively higher Mach Numbers are taken only in small increments and only after exploring accelerated flight characteristics at lower numbers. At each increment in speed an accurate recording is made of essential test data which are analyzed before proceeding to the next step.

Speed Recording. *Flight*, Vol. 53, No. 2050, April 8, 1948, pp. 392, 393, diagrs.

The U.S.A.F. all-altitude speed course uses two vertical radio beams through which the aircraft passes. Air-borne equipment is actuated by the beams and transmits a signal to a ground receiver that incorporates an electronic timing mechanism. A course monitor placed on a surveyed azimuth line 400 ft. from the beam permits directional control accurate to within 8 ft. at 12 miles from the transmitter. To check the azimuth alignment and the vertical lean of the beam, a zenith camera leveled with its optical center over a surveyed point on the course records the indication of an air-borne flash tube that is triggered by the beam.

More About the D.H. 108 Record. *The Aeroplane*, Vol. 74, No. 1924, April 23, 1948, p. 473, illus.

Fuels & Lubricants (12)

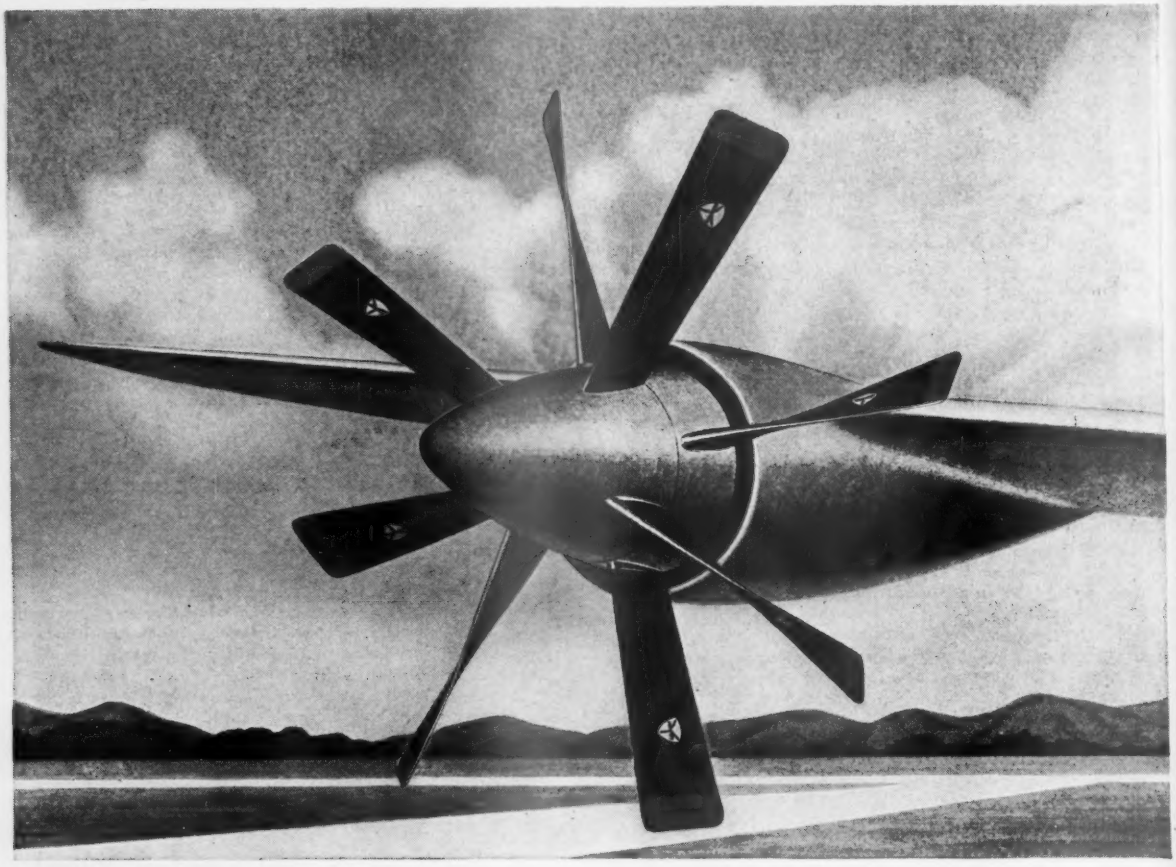
Hydrogen-Peroxide as a Source of Power. René Simard. *Engineering Journal*, Vol. 31, No. 4, April, 1948, pp. 219–225. 1 reference.

A report of the research and development conducted at the Walter Plant, Kiel, Germany, on the properties, manufacture, handling, and storage of high-concentration hydrogen peroxide and methods of employing it as a source of power. Seventeen proposed but undeveloped military projects are reported. A summary of a report originating in the course of this research outlines methods by which a hydrogen-peroxide power plant might be combined with an internal combustion engine to obtain peak performance at high speeds and altitudes without an appreciable reduction in the range or endurance of the aircraft.

Visit to the Chemische und Physische Versuchsanstalt of Kiel, Evacuated to Dänisch Nienhof. S. Masterman. *Combined Intelligence Objectives Sub-Committee, Item No. 4, File No. 33-66.* 33 pp., diagrs. British Information Services, New York. $1.15.

Includes outline of work sponsored by the Oberkommando des Kriegsmarines to develop methods for the production of high-concentration H_2O_2. Projects included studies of the life of catalysts for decomposing H_2O_2, the effect of stabilizers in the peroxide solution, the effect of pretreatment of the catalyst, and methods of catalyst recovery. Techniques were developed for determining the cyanide content of complex copper-cyanide salts and the content of the salt, hydrazine hydrate, and ethyl alcohol in Helman mixture. Sealing materials for use with Helman, Dekalin, and hydrogen-peroxide propellants were being developed from Buna S, Perbunan, and polyvinyl chloride. Specifications for German Naval liquid propellants include methods of sampling, inspecting, and testing and acceptance conditions for hydrogen peroxide, Helman, Helman mixture and its components, and Dekalin.

Japanese Fuels and Lubricants: Fundamental Hydrocarbon Research. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./914*, February, 1946. 98 pp., illus. British Information Services, New York, $3.00.



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Includes two reports: I—On the Physical Properties of Some Pure Hydrocarbons (in Five Parts). S. Komatsu. Pp. 9–94, illus. 20 references. II—Data on the Thermal Cracking of Pure Hydrocarbons. A. Ibuki. Pp. 95–98.

I. Data were compiled on the molecular volume and the cracking temperatures of various hydrocarbons and ultraviolet absorption. Raman spectra were used to study the products of decomposition in an attempt to obtain a correlation between such physical properties as boiling point and molecular volume and the chemical behavior of the compounds. These data, including refractive indices, are tabulated for approximately 100 pure hydrocarbons, 93 per cent of which are in the six to eighteen carbon atom range. The octane numbers of twelve of them have been determined. Includes sections on: The Identification of Hydrocarbons by the Use of Raman Spectra, Some Tabulated Physical Properties of Important Hydrocarbons, Data on the Ultra Violet Absorptive Properties of Some Hydrocarbons, and Data on the Raman Spectra of Hydrocarbons. II. Tabulation of data for 19 compounds.

F-3 and F-4 Engine Tests of Several High-Antiknock Components of Aviation Fuel. Harry S. Imming, Henry C. Barnett, and Russell S. Genco. *U.S., N.A.C.A., Memorandum Report No. E4K27* (*Wartime Report No. E-246*), November, 1944, 81 pp., diagrs.

Correlation of the Characteristics of Single-Cylinder and Flight Engines in Tests of High-Performance Fuels in an Air-Cooled Engine. II—Knock-Limited Charge-Air Flow and Cylinder Temperatures. Kenneth D. Brown, Paul H. Richard, and Robert W. Wilson. *U.S., N.A.C.A., Memorandum Report No. E5J12* (*Wartime Report No. E-272*), October, 1945. 9 pp., figs. 4 references.

Knock-Limited Performance of Pure Hydrocarbons Blended With a Base Fuel in a Full-Scale Aircraft-Engine Cylinder. II—Twelve Aromatics. Arthur W. Bull and Anthony W. Jones. *U.S., N.A.C.A., Advance Restricted Report No. E4I09* (*Wartime Report No. E-225*), September, 1944. 28 pp., figs. 3 references.

Estimation of F-3 and F-4 Knock-Limited Performance Ratings for Ternary and Quaternary Blends Containing Triptane or Other High-Antiknock Aviation Fuel Blending Agents. Henry C. Barnett. *U.S., N.A.C.A., Memorandum Report No. E5A29* (*Wartime Report No. E-250*), January, 1945. 58 pp., diagrs., figs. 5 references.

The Effect of Compression Ratio on Knock Limits of High-Performance Fuels in a CFR Engine. Henry E. Alquist and Leonard K. Tower. **I—Blends of Triptane and 28-R Fuel. II—Blends of 2,2,3-Trimethylpentane With 28-R. III—Blends of 2,3-Dimethylpentane With 28-R.** *U.S., N.A.C.A., Memorandum Reports Nos. E4J10, E5A10, E5B10* (*Wartime Reports Nos. E-245, E-249, E-252*), October, 1944, January, February, 1945. 30; 34; 19 pp.; diagrs., figs. 4, 4, 2 references.

Flight and Test-Stand Investigation of High-Performance Fuels in Double-Row Radial Air-Cooled Engines. III—Comparison of Cooling Characteristics of Flight and Test-Stand Engines. H. Jack White, Calvin C. Blackman, and Marcel Dandois. *U.S., N.A.C.A., Memorandum Report No. E5B23* (*Wartime Report No. E-253*), February, 1945. 32 pp., figs. 6 references.

Flight and Test-Stand Investigation of High-Performance Fuels in Modified Double-Row Radial Air-Cooled Engines. III—Knock-Limited Performance of 33-R as Compared with a Triptane Blend and 28-R in Flight. Calvin C. Blackman and H. Jack White. *U.S., N.A.C.A., Memorandum Report No. E5H08* (*Wartime Report No. E-263*), August, 1945. 20 pp., figs. 2 references.

Knock-Limited Blending Characteristics of Blends of Triptane and 28-R Aviation Fuel. John C. Evvard, Harry S. Imming, and Russell S. Genco. *U.S., N.A.C.A., Memorandum Report* (*Wartime Report No. E-242*), April, 1944. 23 pp., figs. 2 references.

Gliders & Gliding (35)

Soaring in France; The New High Performance Sailplanes "Air 100" and "S.A. 140." Guy Borge. *Sailplane and Glider*, Vol. 16, No. 4, April, 1948, pp. 8, 9, illus., figs.

Two-Seat Sailplanes. W. Czerwinski and B. S. Shenstone. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 46–48, 98, illus., diagrs. A design description of the Harbinger two-seated sailplane. Some details of other sailplanes are offered for comparison.

Guided Missiles (1)

Projectile Shapes for Smallest Wave Drag. W. Haack. (*LGB 139*, pp. 14–37.) *Brown University, Graduate Division of Applied Mathematics, Translation No. A9-T-3* (*Advance Copy*), 1948. 53 pp., diagrs. 10 references.

An analysis of von Kármán's approximate theory of gas flow about slender bodies of revolution shows that its use for the calculation of the configuration of projectile noses that have minimum wave drag introduces no significant errors and that no essentially different shapes would be obtained by using the exact equation. Taking caliber, volume, and length successively as variable with the other two parameters remaining fixed, formulas were obtained for the shape of projectiles and projectile noses of minimum drag. Wind-tunnel measurements at 2 Mach carried out on optimal projectiles shapes based on equal volume and equal length showed a better agreement with theory than was expected and exhibited the same behavior as the calculated values.

Comparison of Drop and Wind-Tunnel Experiments on Bomb Drag at High Subsonic Speeds. B. Göthert. (ZWB/FB/1570, April 17, 1942.) *U.S., N.A.C.A., Technical Memorandum No. 1186*, May, 1948. 12 pp., figs.

The path and rate of descent of bombs dropped from a height of 11 km. were recorded by phototheodolites. A maximum velocity 97 per cent of the speed of sound was attained. The variation of the drag coefficients of the bombs agreed closely with measurements made in the closed high-speed wind tunnel of the DVL. Comparison with measurements made in the open jet of the AVA, Göttingen, however, showed that the lack of correction factors for the velocity and the low Reynolds Number of the tunnel caused too low a value to be given to the steep increase in drag which takes place as the velocity of the falling body approaches the velocity of sound.

Planetary Properties of Fast Cars. A. F. Zahm. *Franklin Institute, Journal*, Vol. 245, No. 4, April, 1948, pp. 331–336, 3 references.

A discussion of the variation of weight and buoyancy, radial acceleration, and surface heating and pressure effects with altitude and velocity. The cost of the kinetic energy required to propel a planetary vehicle around the earth and outside the atmosphere at a rate of 1 mile per sec. would be $10,000. The attitude of the ship with respect to an axis normal to the earth's surface could be changed by rotors mounted internally which would impart their momentum to the ship.

Installations

SHIPBORNE (28)

Jet Plane Problems on Aircraft Carriers. *Western Flying*, Vol. 28, No. 5, May, 1948, pp. 9, 18, illus. A summary of the problems encountered with North American JF-1 fighters aboard the U.S.S. "Boxer."

Instruments (9)

The Physical Principles of Some Basic Aircraft Instruments. W. H. Hoather. *Journal of Scientific Instruments*, Vol. 25, No. 4, April, 1948, pp. 113–122, illus., figs.

The design and construction of typical aircraft instruments are described, as well as the physical principles and formulas of pressure-sensitive altimeters, air-speed indicators, true air-speed indicators, Mach meters, maximum safe air-speed indicators, and rate-of-climb indicators. Because of the inherent relationships that exist among pressure, density, temperature, and altitude factors, each instrument must incorporate suitable compensating elements to ensure accurate indication under differing flight conditions. Engine speed indicators generally employ an engine-driven generator and a synchronous servomotor acting on a magnetic-drag mechanism rather than a mechanical system. A measure of the difference in speed between engines of a multiengined airplane can be supplied by the rotation of a synchronous servomotor having two windings on the rotor, each excited by a different engine-driven generator. The features in the design of an aircraft magnetic compass are indicated which are necessary to accommodate for acceleration, northerly turning error, and variation in the dip of the earth's magnetic field.

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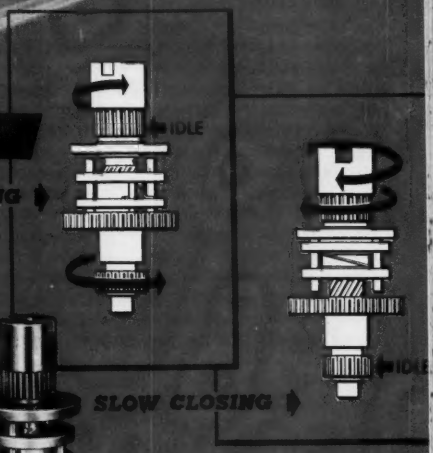

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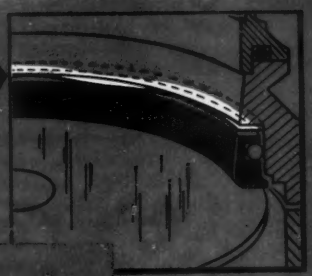

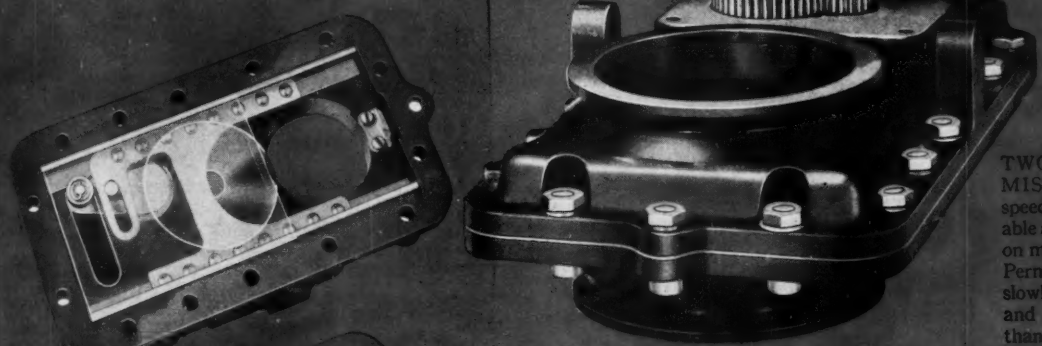

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Automatic Aircraft Control. James L. Anast. *Aeronautical Engineering Review*, Vol. 7, No. 7, July, 1948, pp. 20–24, illus., figs.

Brief descriptions of the functions of the master sequence selector, magnetic heading selector, radio compass controller, automatic engine control system, pitch attitude selector, constant air-speed control, landing gear and flap control, altitude control, localizer and glide path control, altitude sensor, the air-mile counter and the localizer and glide path sensors which comprise the experimental automatic flight control installation of the All-Weather Flying Division of the Air Materiel Command. An account of the recent flight from Stephenville, Newfoundland, to Brize Norton, England, which was divided into twelve operational phases, illustrates the functions of the prototype Automatic Flight Controller. Each phase and the control parameters it required were preset in the master sequence selector, which initiated each phase in turn and issued appropriate control commands. The automatic flight controller is a system of radio station homing and air position control. Automatic navigation control is under development.

Flight Path Control. Paul A. Noxon. *Aeronautical Engineering Review*, Vol. 7, No. 8, August, 1948, pp. 38–45, figs. 7 references.

A study of the automatic approach control showing the compromises required in a typical solution by the geometry of the problem and the characteristics of the equipment and radio technique. In order to avoid accurate preset data and compensation for cross wind in a system operating with an ILS localizer beacon, a "wash out" is used to supply integration of the attitude of the airplane with time for an observed error. The system instability at large values of slant range is compensated by a phase-advance or rate system. This system, because it impairs the long period sensitivity of the system, requires an additional element, long-period signal integration, to compensate for residual airplane turning moments. A limit, however, is imposed on the initial error that can be tolerated by the system by the narrow range in which the proportionality of the signal beam is reliable and by attitude effects, which during banked turns distort the apparent position of the beam and destroy stability.

Designing Instrument Gearing. Louis D. Martin. *Machine Design*, Vol. 20, No. 4, April, 1948, pp. 163–168, illus., diagrs.

Basic considerations for the design of involute gears of fine pitch which are used essentially to transmit motion rather than power. The ratio and the kind of drive needed to obtain the correct speed and direction of motion determine whether the train will consist of spur, helical, bevel, face, or hypoid gears. Includes: selection of the tooth form system; advantages and disadvantages of the standard center distance system and the enlarged center distance system; the specification of gear centers; and standard tolerances and backlash specifications.

Précis of a Discussion on "Practical Considerations in Instrument Design"—London, 1948. *Journal of Scientific Instruments*, Vol. 25, No. 4, April, 1948, pp. 122–124, diagr.

Laboratories, Aeronautical (50)

Instruments in Aeronautical Research. S. J. Murphy. *Canada, National Research Council, Aeronautical Laboratories, Quarterly Bulletin, Report No. ME 1948 (1)*, January 1–March 31, 1948, pp. 1–6, illus.

Typical instruments developed by the National Research Laboratories which require either special sensing elements, transmission systems, or indicating and recording components, include a group of film-strip recorders synchronized by a common timing circuit which was used for the complete instrumentation of the N.R.L. tailless glider. The cloud-droplet camera is used both in meteorological investigations and in the study of ice formation on jet engines. It contains a rotating prism that compensates for the relative motion of the water droplets and the camera. The stroboviewer enables continuous observation of the propeller blades during icing studies. The stroboscope disc is driven by and synchronized with the engine. A stall warning indicator detects impending reversal of the airflow over the wing by bleeding the flow to a hot-wire anemometer inside the wing. The two wires of the anemometer are separated by a heating element. During normal airflow the differential cooling keep a bridge circuit in balance. When the flow lessens or is reversed, the change in

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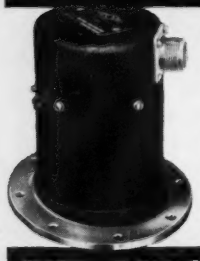

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London : W.C.1 England

temperature differential actuates a warning system. Calibration facilities of the laboratories are mentioned.

Stream Line. Gordon Williams. *Boeing Magazine*, Vol. 18, No. 4, April, 1948, pp. 10, 11, illus.

The propulsion development unit of the Boeing Airplane Company is using Birefringent Flow Study Models. Water containing suspended Bentonite clay flows through a test section 48 in. long, 5 in. high, and 1.5 in. wide past miniature models. Polarized light is projected through the plexiglass-walled test section, and the flow pattern is recorded with a 16-mm. motion-picture camera operating at 3,000 frames per sec.

Research! Martin Engineers Explore New Realms of Flight. J. M. Jacobson. *The Martin Star*, May, 1948, pp. 3, 18, 19, illus.

Current Projects in Aerodynamics Laboratory, Aircraft and Allied Instruments Laboratory, Engine Laboratory, Flight Research Section, Gas Dynamics Section, Gasoline and Oil Laboratory, Hydrodynamics Laboratory, Low Temperature Laboratory, and Structures Laboratory. *Canada, National Research Council, Aeronautical Laboratories, Quarterly Bulletin, Reports Nos. ME 1947(4), ME 1948(1)*, October 1–December 31, 1947, January 1–March 31, 1948, pp. 8–22; 7–22; illus.

Laws & Regulations (44)

Uniformity in Air Safety Regulation: Cooperative Federalism Applied. Louis E. Black, Jr. *Journal of Air Law and Commerce*, Vol. 15, No. 2, Spring, 1948, pp. 181–200.

An outline of the development of legislation pertaining to the operation of aircraft shows that federal jurisdiction has become intensive and exclusive. The enactment by the states of parallel legislation rather than legislation serving to implement the federal statutes has imposed double penalties on the aircraft operator. An amendment to the Civil Aeronautics Act is proposed which, conforming to established juridical precedent, would give to the state authorities the power and the obligation to enforce existing federal statutes. Such a policy would guarantee uniform safety regulations throughout the country and decentralization of enforcement, and would prevent the concurrent operation of federal, state, and municipal sanctions.

Creation and International Recognition of Title and Security Rights in Aircraft. G. Nathan Calkins, Jr. *Journal of Air Law and Commerce*, Vol. 15, No. 2, Spring, 1948, pp. 156–180.

Limitations on Charter Services as Authorized Under Section 401 (f) of the Civil Aeronautics Act of 1938. *Journal of Air Law and Commerce*, Vol. 15, No. 2, Spring, 1948, pp. 238–243.

Economic Regulation of Irregular Air Carriers. Armory O. Moore. *Journal of Air Law and Commerce*, Vol. 15, No. 2, Spring, 1948, pp. 231–238.

The Position of the State in Economic Control and Regulation of Air Commerce. George W. Starr. *Journal of Air Law and Commerce*, Vol. 15, No. 2, Spring, 1948, pp. 127–155.

Blackjacking the Pilot. Curtis Fuller. *Flying*, Vol. 42, No. 5, May, 1948, pp. 18, 56, 58, 60, 62, illus.

A discussion of the difficulties experienced by private pilots which are described as being caused by the overlapping jurisdiction of the C.A.A. and the C.A.B.; the lack of uniformity in the enforcement policy of the nine C.A.A. regions; and the imposition, in lieu of civil penalties, of compromise settlements for alleged violations of the C.A.A. regulations.

Wings Across the Border: Procedure for Americans Flying to Canada; Procedure for Canadians Flying to the U.S. *Canadian Aviation*, Vol. 21, No. 5, May, 1948, pp. 30–33.

Lighter-Than-Air (40)

New Balloons Explore Roof of the Airways. Devon Francis. *Popular Science*, Vol. 152, No. 5, May, 1948, pp. 99–104, illus.

The launching and observation of one of the high-altitude balloons used by the Aeronautical Research Laboratories of General Mills to obtain meteorological data at 100,000 ft.

Machine Elements (14)

Why **Aircraft Use Anti-Friction Bearings.** H. O. Smith. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 54, 55, 76, 78, 94, illus.

The advantages of using antifriction bearings in aircraft power plants, accessories, instruments, and parts.

Maintenance (25)

German Aircraft Maintenance. (*Combined Intelligence Objectives Sub-Committee, Report No. 25-45.*) *Aircraft Engineering*, Vol. 20, No. 230, April, 1948, pp. 102–104.

The organization of the Luftwaffe separated the operational organization from the administrative and supply organization. This division, extensive practical training of maintenance personnel, and the deliberate attempt to design aircraft for simplicity of maintenance and replacement were the outstanding advantages of the German system. Maintenance, however, did not ordinarily include major overhaul. This was handled by civilian contractors. Information is included on typical maintenance practice.

Servicing Dock Deluxe. *Aviation Maintenance & Operations*, Vol. 9, No. 5, April, 1948, pp. 24, 25, illus.

A tubular-steel scaffolding supporting nonskid steel mesh runways facilitates the maintenance and inspection of the exterior Constellation Clippers. Spare parts and tool cabinets, electric and hydraulic power, and searchlights are an integral part of the scaffolding.

Keep Those Trainers Flying. Herb Packer. *Aviation Maintenance & Operations*, Vol. 9, No. 5, April, 1948, pp. 21–23, illus.

An outline of the normal maintenance and replacement required at the 25-, 100-, 500-, and 1,000-hour inspections during the first 1,500 hours of service of a Piper Cub trainer. The Schumacher Flying Service replaces its aircraft on the average of every 2 years and during this time operates each aircraft about 1,500 hours.

Servicing Tips for Airliners. XX—Propellers. Allen Merkin. *Aviation Maintenance & Operations*, Vol. 9, No. 5, April, 1948, p. 36. For the Douglas DC-6 and DC-4.

Airline-Information Please. Walter L. Flinn. *Aviation Maintenance & Operations*, Vol. 9, No. 5, April, 1948, pp. 30–33, illus.

A periodical newsletter for air-line personnel containing current and accurate information will increase morale and supplement the dissemination of maintenance and engineering data.

Douglas Service, Vol. 6, No. 5, May, 1948. 20 pp., illus., diagrs.

Contents: Engine Shock Mounts, DC-4—Latest Information on Cleaning, Inspection and Installation. Water/Alcohol Plug, DC-6—Check for Removal of Plug. Cabin Supercharger Test Panel, DC-6. Fire Protection Equipment, DC-6—Description of Latest Changes in Mechanical and Electrical Systems. Fenwal Test Block, DC-4, DC-6—Adjustment Procedures for Heater Temperature Control and Fire Detector Switches. Service Hints, DC-6—Wing-to-Nacelle Fillet Fuel Leaks Elevator Tab Jackshaft. Cabin Pressure Amplifier Tester, DC-6—Ground and Flight Check-Out of Cabin Pressure Control Circuit. Leaky Brakes, DC-4—Reboring Worn "O" Ring Cavity. Storage Batteries—Specific Gravity Test and Trouble Shooting Chart. Gust Lock Unlocked, DC-4, DC-6.

Management & Finance (45)

New Rules Set For Aircraft Procurement. *Aviation Week*, Vol. 48, No. 17, May 3, 1948, pp. 9, 10. Outline of allowable and unallowable costs under the proposed Government procurement contract policy.

Materials (8)

METALS & ALLOYS

Effects of Surface Finish, of Certain Defects, and of Repair of Defects by Welding on Fatigue Strength of 355-T6 Sand-Castings and Effects of Prior Fatigue Stressing on Tensile Properties. F. M. Howell, G. W. Stickley, and J. O. Lyst. *U.S., N.A.C.A., Technical Note No. 1464*, April, 1948, 49 pp., illus., tables. 2 references.

The results of fatigue tests of 355-T6 sand-cast plate-type specimens that did not fail showed the fatigue strength of normally sound castings with as-cast surfaces to be about 70 per cent of the fatigue strength determined by using small polished round specimens tested in direct stress. These fatigue strengths were increased about 35 per cent by shot-blasting or grit-blasting surface treatments. In the as-cast condition porosity from 0.8 to 2.4 per cent had no effect on fatigue strength, but a decrease of 15 per

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cent was noted when the porosity exceeded this range. Sand holes 1/4 in. and 1/8 in. in diameter reduced the fatigue strength more when located at the edge than when located near the center of the specimen. Dross inclusions behaved in a similar manner but, like intentional defects that were produced by inserting aluminum strips on edge in the molds before casting, were harmful when oriented transversely but not when oriented longitudinally. While the fatigue resistance of castings having defects was improved or completely restored by welding and reheat-treating, the tensile strength was reduced by about 4 per cent. Neither grit blasting the surface or the fatigue testing reduced the tensile properties of the specimens. Shot blasting, however, lowered the tensile strength about 9 per cent but increased the yield strength slightly. Both the sound and the porous specimens with as-cast surfaces displayed tensile strengths and elongations in close agreement with the properties of separately cast test bars.

Which Wrought Stainless Steel? II—Fitting the Material to the Part. Stanley P. Watkins and Roland J. Berkol. *Machine Design*, Vol. 20, No. 4, April, 1948, pp. 174–179, illus.

Descriptions of the corrosion and heat resistance, cold-working properties, heat-treatability, machinability, and applications of 29 types of chromium-nickel, martensitic-chromium, and ferritic-chromium steels.

Steel Heat Treating Processes and Equipment. S. D. Smoke. *Materials & Methods*, Vol. 27, No. 4, April, 1948, pp. 93–104, illus., tables.

Widia Tungsten Carbide. E. M. Wilson. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 1694, Item Nos. 21, 31*, May, 1947. 7 pp. British Information Services, New York. $0.35. Production and testing techniques used by Krupp A.G. Widia-fabrik in the manufacture of tungsten, titanium, and tantalum carbides.

Stress-Strain and Elongation Graphs for Alclad Aluminum-Alloy 24S-T Sheet. James A. Miller. *U.S., N.A.C.A., Technical Note No. 1512*, May, 1948. 37 pp., figs. 7 references.

Graphs are presented from tests of duplicate longitudinal and transverse 0.032-, 0.064-, and 0.125-in. thick Alclad aluminum-alloy 24S-T sheet specimens of tensile and compressive stress-strain and stress-deviation to a 1 per cent strain, tangent modulus and reduced modulus for a rectangular section against stress in compression, stress-strain of tensile specimens tested to failure, and local elongation and elongation against gage length for tensile specimens tested to fracture. The stress-strain, stress-deviation, tangent modulus, and reduced modulus graphs are plotted on a dimensionless basis to make them applicable to material with differing yield strengths.

Stress-Strain and Elongation Graphs for Alclad Aluminum-Alloy 24S-T81 Sheet. James A. Miller. *U.S., N.A.C.A., Technical Note No. 1513*, May, 1948. 36 pp., figs. 8 references.

Heat Treatment of Aluminum Alloys. R. W. Kerr. *The Technical Instructor*, Vol. 3, No. 4, April, 1948, pp. 13, 14. A brief outline of the behavior of aluminum alloys during heat-treatment and age hardening, with a table of the minimum bending radii of light alloys.

Surface Oxide Removal Important in Final Processing of Aluminum. D. E. Durkin. *Materials & Methods*, Vol. 27, No. 4, April, 1948, pp. 82–85, figs., tables.

Chromium-sulfuric, chromium-phosphoric, hydrofluoric, and three acid-type compounds were examined to determine their suitability as oxide removing agents to be used in the preparation of aluminum surfaces for resistance welding, anodizing, and chromating. All of the reagents, except one of the acid-type compounds, were found to be unsatisfactory for one or more of the following reasons: Oxide removal was inadequate giving high surface resistance values; removal was not uniform; immersion time was critical endangering the aluminum surface to attack by the reagent; and reoxidation was not inhibited sufficiently to allow for normal interval before subsequent processing.

The Corrosion of Metals. IX—Magnesium and its Alloys. *Sheet Metal Industries*, Vol. 25, No. 253, May, 1948, pp. 963–970, 978, figs., 13 references.

A.S.T.M. Code Systems for Aluminum Alloys and Magnesium Alloys. R. B. Smith. *American Society for Testing Materials, Bulletin*, No. 151, March, 1948, pp. 50, 51.

What's in an Alloy? John C. Kiszka. *American Society for Testing Materials, Bulletin*, No. 151, March, 1948, pp. 51–54.

A proposed method for designating nonferrous alloys. The code provides for each alloy a unique designation that indicates the base metal, the percentage of the two principal alloying elements, and the number of additional constituents.

A General Survey of the German Non-Ferrous Industry. A. Schwarz, R. K. Mehta, and P. Majumdar. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 1660, Item No. 21.* 51 pp., figs. British Information Services, New York. $1.60.

Ductility Testing of Sheet Metals. D. W. Richardson. *The Technical Instructor*, Vol. 3, No. 4, April, 1948, pp. 11, 12.

NONMETALLIC MATERIALS

Effect of Simulated Service Conditions on Plastics During Accelerated and 2-Year Weathering Tests. W. A. Crouse, D. C. Caudill, and F. W. Reinhart. *U.S., N.A.C.A., Technical Note No. 1438*, May, 1948. 8 pp. 2 references.

The effects of outdoor weathering for 2 years and of an accelerated weathering test on the weight, dimensional stability, and flexural properties of selected reinforced plastics were investigated. None of the laboratory aging tests correlated with outdoor weathering with respect to all properties and all materials.

Investigation of German Aircraft Protective Coatings. *Gt. Brit., British Intelligence Objectives Sub-Committee, Miscellaneous Report No. 54*, September, 1945. 13 pp. British Information Services, New York. $0.55.

A survey of German research, development, and production techniques between 1938 and 1945 in the protective coating and surface treatment of aluminum, magnesium, steel, and fabric components of aircraft and sealants for fuel tanks, floats, and pressurized cabins.

High-Temperature Ceramic Coatings for Steel. *Steel Processing*, Vol. 34, No. 5, May, 1948, pp. 245–247, illus. 1 reference. N.B.S. coatings.

Some Factors Affecting Adhesive Bond Formation. H. P. Meissner and E. W. Merrill. *American Society for Testing Materials, Bulletin*, No. 151, March, 1948, pp. 80–83, figs. 13 references.

Meteorology (30)

A Meteorological Measure of Maximum Gust Velocities in Clouds. I. I. Gringorten and H. Press. *U.S., N.A.C.A., Technical Note No. 1569*, April, 1948. 20 pp., figs. 13 references.

From an analysis of the energy transformations in convective clouds a meteorological parameter was obtained for gustiness in clouds, which was a simple function of the height of convective activity and the horizontal temperature spread. Correlation coefficients of about 0.7 were obtained between observed values of the maximum gust velocities and this parameter. It also appears to give short-range forecasts that are correct within 10 ft. per sec., 95 per cent of the time, or within 5 ft. per sec., 67 per cent of the time, when used within the scope of the data presented.

A Method of Using Pilot Reports for Ocean-Area Synoptic Analysis. C. K. Stidd. *American Meteorological Society, Bulletin*, Vol. 29, No. 2, February, 1948, pp. 56–60, figs.

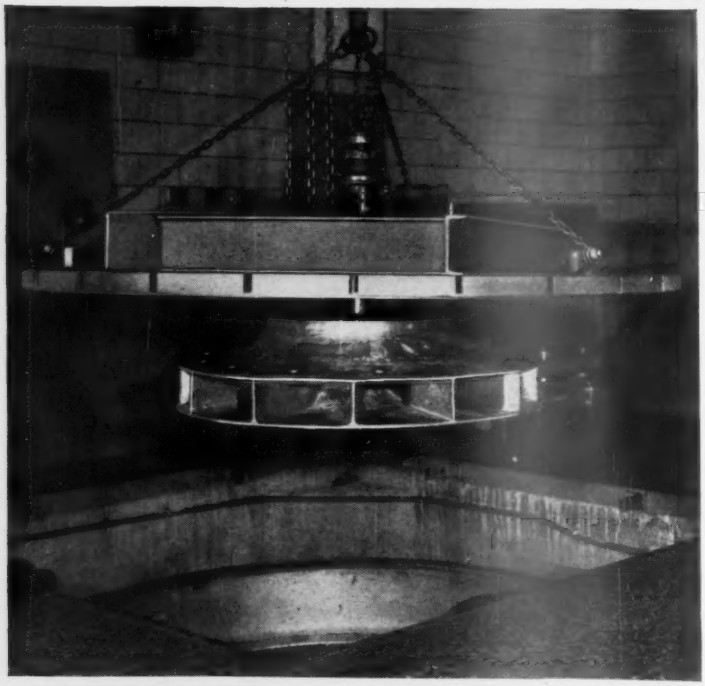
Effective use can be made of the weather reports taken by aircraft flying over ocean areas. By plotting the data on a chart the abscissa values of which are time in hours and the ordinate values are degrees of longitude, the variation in the weather at a given location or the path of a specific disturbance can be determined. When the difference in reading between the pressure and the radio altimeter is plotted, the points of minimum value can be used to locate troughs of low pressure. These can provide a display of easterly thoughts or other weak systems. From the chart it is possible to detect inconsistent reports and to make a simple prognostic chart.

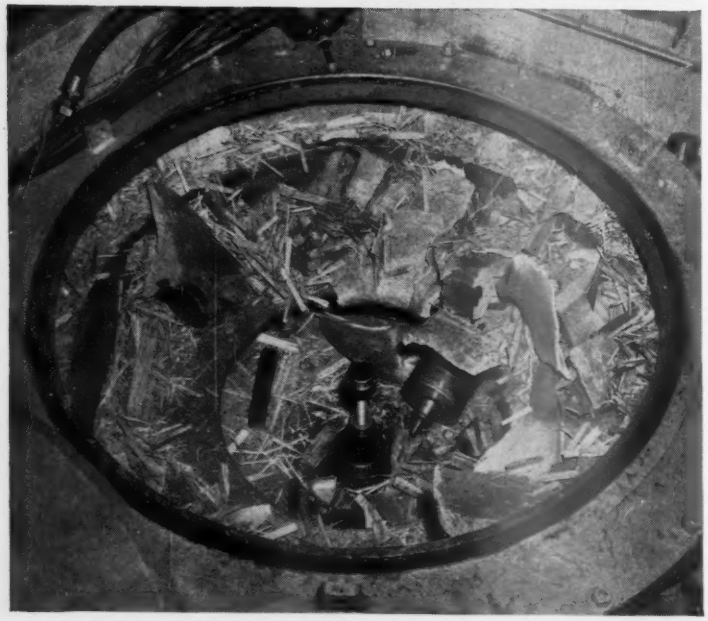
Weather Facsimile Network Development. *Plane Facts*, Vol. 5, No. 3, March, 1948, pp. 16, 32.

The Air Force and the Army Signal Corps have developed a network of telephotography transmission channels by which it will be possible to transmit weather maps from a main control point at Arlington, Va., on a half-hourly basis. The service will provide the forecasters at Air Weather Service Stations with comprehensive data that can be developed into local and route forecasts without further plotting.

Polar Met. Stations. Frank Illingworth. *Flight*, Vol. 53, No. 2053, April 29, 1948, pp. 47, 471, illus. A survey of the meteorological stations and services being established in the north polar regions.

Impeller Whirled to Destruction!





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As the rotating part tends to replace the reciprocating part in aircraft engines and accessories, the question of correct design of impellers and similar parts for high-speed operation is assuming increasing importance.

Aircraft engineers are working with speeds of 30,000 r.p.m. and upward on large-size parts; considering peripheral speeds approaching 12,000 feet per second on parts of all types.

What is the factor of safety in such parts? The answer comes two ways: with destruction tests such as that shown here, in which speeds up to 87,000 r.p.m. have been recorded, or with continued runs well above the required speed of the part, by which safe performance at operating speed is assured. Stress-coating of such parts for experimental runs adds to the designer's knowledge.

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An Analysis of the Wind and Temperature Distribution in the Free Atmosphere Over North America in a Case of Approximately Westerly Flow. E. Palmen and K. M. Nagler. *Journal of Meteorology*, Vol. 5, No. 2, April, 1948, pp. 58–64, figs. 5 references.

On the Forecasting of Long Waves in the Upper Westerlies. George P. Cressman. *Journal of Meteorology*, Vol. 5, No. 2, April, 1948, pp. 44–57, figs. 11 references.

The Magnitude of Radiative Heating in the Lower Stratosphere. Frederic C. E. Older. *Journal of Meteorology*, Vol. 5, No. 2, April, 1948, pp. 65–67, tables. 8 references.

An Essay on the General Circulation of the Earth's Atmosphere. Victor P. Starr. *Journal of Meteorology*, Vol. 5, No. 2, April, 1948, pp. 39–43, figs. 5 references.

Operations

COMMERCIAL (41)

Air Cargo Refrigeration. L. R. Hackney. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 37–39, 106, 108, 109, 110, figs. 9 references.

The type of refrigerated cargo and the periods during which it will be carried determine whether an integral refrigeration unit in the cargo compartment of an airplane or a quickly removable packaged unit will be more efficient. The same factors also determine whether it is more efficient to have complete or partial insulation of the compartment or to use insulated refrigerated containers. Both vapor and air-cycle refrigerators have been installed in aircraft. Although the vapor-cycle system is quieter and requires less power than the air-cycle system, it is larger, heavier, requires defrosting, and operates with a high refrigerant pressure. The simplest refrigeration system that has been installed uses dry ice as a coolant. In this system the air in the cargo compartment is either circulated directly over the dry ice or a secondary alcohol circuit is used.

Aircargo Container Developments. Jack Geddie. *Distribution Age*, Vol. 47, No. 4, April, 1948, pp. 28, 29, 91, illus. Comparison of examples of containers developed from plywood, solid and corrugated fiberboard, veneer-kraft laminate, pliofilm, and plastics.

The Air Freight Agent. *The Aeroplane*, Vol. 74, No. 1925, April 30, 1948, p. 510, illus.

International Air Express. John H. Frederick. *Distribution Age*, Vol. 47, No. 4, April, 1948, pp. 45, 67, illus.

The limit of 5 per cent placed by the International Air Transport Association on the commissions of cargo service sales agents for its member air lines was not acceptable to the Railway Express Agency, which requested a guarantee of $1.00 commission per shipment. The subsequent cancellation of international air-express contracts with the major international air lines has diverted over 90 per cent of the U.S. import and export air cargo business to a great number of widely dispersed freight forwarders with whom the air lines must deal individually.

North Atlantic Refuelling Trials; An Answer to Two Queries. Sir Alan Cobham. *Flight*, Vol. 53, No. 2051, April 15, 1948, p. 408, illus.

The success of the Bermuda flight-refueling trials shows that such operations are practical. Of the problems involved, only 20 per cent pertain to the actual refueling. The remainder consist of flight planning, instrument flying, and bad-weather operation of the tanker. The chief objection to this operation comes from pilots who have not had experience in formation flying. That this type of flying is not inherently dangerous is shown by the record of the Fighter Command for 1946 when only one accident during formation flying was recorded for 20 accidents during take-off and landing.

Test Flight Refuelling on Montreal-London Run. Basil Clarke. *Aircraft and Airport*, Vol. 10, No. 4, April, 1948, pp. 35–37, illus.

Trans Canada With T.C.A. Roy Pearl. *Flight*, Vol. 53, No. 2052, April 22, 1948, pp. 439–442, illus.

Development of Pakistan Airlines. *Indian Aviation*, Vol. 32, No. 2, February, 1948, p. 42.

Twelve Years of Progress; Development of Irish Airlines. III—Ground Organization and Traffic. *Modern Transport*, Vol. 59, No. 1515, April 10, 1948, p. 9, illus.

Personal Flying (42)

On Light Aeroplanes. Roger Tennant. *The Aeroplane*, Vol. 74, No. 1924, April 23, 1948, p. 487.

A discussion of the British light-airplane market, its future requirements, and the comparative suitability of the Ercoupe, Navion, Bonanza, Prestwick Pioneer, and the Seabee for this market.

Fast or Tight Turns? John R. Hoyt. *Flying*, Vol. 42, No. 5, May, 1948, pp. 28, 48, 50, illus. An analysis of the relationships that exist among the air speed, bank, and rate of turn of an airplane.

Photography (26)

Synchronized Microtime Photography. *U.S., Naval Ordnance Test Station, Michelson Laboratory, Inyokern, Calif., Release*, May 8, 1948. 8 pp., diagrs.

Operating principles and applications of the RC-4 76-lens Bowen revolving mirror camera, the time-resolved spectrograph, the RC-3 camera system, high-speed spark shadowgraph, the Eastman high-speed standard type III, and the high-speed oscillograph. The Zarem electro-optical shutter camera employs two polarizers set for minimum transmission of light to the object separated by a Kerr cell. This cell contains two electrodes sealed in an atmosphere of nitrobenzene. The application of voltage to the electrodes causes alteration in the state of polarization of the light being transmitted through the cell. The light transmitted by the second polarizer to the object depends therefore on the voltage applied to the electrodes and the effective open time of the shutter is determined by the rapidity with which the voltage can be applied and removed. Effective exposure times of 0.00000001 sec. have been obtained. A number of Kerr cell shutters pulsed in rapid succession have given framing rates of 40,000,000 frames per sec.

An Approach to Exterior Orientation. O. M. Miller. *Photogrammetric Engineering*, Vol. 14, No. 1, March, 1948, pp. 155–179, figs. 6 references.

The angular exterior orientation of a photograph at the moment of exposure can be established by transformation of one system of rectangular coordinates to another. A system of notation is utilized which makes it possible to develop quickly and simply, in terms of coordinate differences, the general perspective relationships that are independent of the position of the air station. An explicit and general method is developed for computing the azimuth of the principal plane, the tilt, and the swing that requires six control points to be imaged on the photograph, the elevations of at least two of which differ from those of the others. By this method a field determination of the principal distance may be determined. Two iterative methods are derived from the same fundamental formulas used in the explicit method, one for obliques and the other for near verticals. Both of these require not more than three control points, and their efficiency is not dependent on the nature of the terrain imaged. All illustrative example is worked out for each method. These techniques are particularly suited to mechanical computation.

Photo Maps Speed Planning; Aerial Survey in Australian State. John Loughlin. *Indian Aviation*, Vol. 32, No. 2, February, 1948, 44–46, map.

Proceedings of the 1947 Annual Meeting, American Society of Photogrammetry. *Photogrammetric Engineering*, Vol. 14, No. 1, March, 1948, pp. 5–126, illus., diagrs., figs.

Contains the text and discussions of the following papers: The National Mapping Program, Robert H. Randall. Kelsh Plotter, Harry T. Kelsh. Photogrammetry and Highways, William T. Pryor. A New Method of Map Compilation for Color Printing, Newman Bumstead. Application of Terrestrial Photogrammetry to Multiplex Heighting in Canada, J. I. Thompson. Equipment and Methods Employed by the Hunting Group of Air Survey Companies, F. L. Wills. Military Mapping, W. H. Mills and Albert L. Nowicki. Reconnaissance Mapping with Photoalidade, David Landen. Procedural Developments in Trimetrogon Compilation, Sidney A. Tischler. Education in Photogrammetry (Panel Discussion). The Helicopter, A Flying Tripod, V. R. Short. Negative Quality Required for Stereo-Plotting Instruments, William Harmon. Value and Application of Research in Photogrammetry, James E. Henry. Radar Charting, A New Application of Photogrammetry, G. J. Podeyn.

Air Survey and Photogrammetry in British Columbia. G. S. Andrews. *Photogrammetric Engineering*, Vol. 14, No. 1, March, 1948, pp. 134–153, illus, figs. 24 references.

Power Plants

JET & TURBINE (5)

Flight Thrust Analysis. I, II. Albert W. Gabriel, Jr. *Aero Digest*, Vol. 56, Nos. 4, 5, April, May, 1948, pp. 60, 62, 65, 66, 106; 70–72, 74; figs. 1, 2 references.

I. Practical methods of determining the theoretical values for the exhaust-gas flow, final exhaust-gas velocity, gross thrust, and the calibration coefficient of each value for a particular installation. Actual values are obtained by combining the curves for the theoretical values with the curves for their coefficients. The method is developed from basic principles for an elementary installation and may be used with minimum or complete instrumentation. Examples are worked throughout to demonstrate the use of formulas and curves. **II.** A method of calculating the thermal cycle of a turbojet engine. These calculations indicate approximate values for data taken at selected stations and can be used as a check to detect erroneous data. Equations for the flow and the velocity of the air passing through the engine are derived and from them an equation is obtained for the thrust.

Instrumentation for Engine Testing. *Aviation Week*, Vol. 48, No. 19, May 10, 1948, pp. 27, 28, illus.

The Northrop-Hendy Company have developed a mass instrumentation technique for the Turbodyne they have under development which has reduced their laboratory costs by two-thirds. Data from 380 pressure take-offs at compressor and turbine stages and at the multiple burners, and from 100 temperature take-offs in combustion areas and at bearing surfaces, and horizontal, vertical, and axial vibration data at four stations are recorded simultaneously. The multiple-camera recordings are coordinated by Veeder-Root counters synchronized to a master counter and clock. An entire test run is made with a staff of ten men. Output of the gas turbine is tested against a power-absorbing compressor.

A Preliminary Evaluation of the Explosion Jet-Propulsion Engine. J. C. Sanders. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. E-243)*, August, 1944. 22 pp., illus., figs. 7 references.

Theoretical calculations of the thermodynamic cycles for an explosion jet-propulsion engine (intermittent-jet) and a constant-pressure jet-propulsion engine indicate that the combined efficiency of the explosion-jet engine (cycle efficiency times propulsive efficiency) is 8 to 10 per cent as compared with 3 to 11 per cent for a constant-pressure engine at a maximum gas temperature of 1,600°F. and an aircraft speed of 400 m.p.h. The explosion-jet engine is more efficient than the constant-pressure jet engine at pressure ratios below 3.0. Supercharging up to a pressure ratio of 4 increases the efficiency of the explosion-jet engine. The power absorbed by the compressor in the explosion-jet engine is less than in the constant-pressure jet-propulsion engine.

Vibration Problems in Gas Turbines, Centrifugal and Axial Flow Compressors. J. F. Shannon. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2202*, March, 1945. 46 pp., illus., figs. 26 references. British Information Services, New York. $3.00.

Failure of the blading, impeller vanes, and combustion chambers of gas turbines have been traced to vibration fatigue. In the case of compressor blades aerodynamic damping accounts for 60 per cent and material and blade root provide 20 per cent each of the total damping in the system. In turbine blades, the blade root supplies 70 per cent of the damping, the remainder being supplied by aerodynamic and material damping. Experimental methods have been devised for fatiguing blades at resonance to reveal weakness in blade and root design.

Symbols for Turbojet and Turboprop Engines. *Aero Digest*, Vol. 56, No. 4, April, 1948, p. 59.

A list of symbols for the common variables, constants, relationships, concepts, parameters, and the customary dimensions used in the analysis of gas-turbine engines. The list was compiled by Westinghouse engineers for the American Standards Association and the Aircraft Industries Association.

Leadership in Future Air Travel; Destiny of Jet Transport. James C. Floyd. *Canadian Aviation*, Vol. 21, No. 5, May, 1948, pp. 26, 27, 74, 76, 78.

A comparison of the cost of operating a jet-powered high-speed aircraft and a reciprocating-engined medium-speed aircraft show that in spite of the higher hourly rate of fuel consumption of the jet engine the operating cost per mile is considerably lower. The higher speeds of a jet transport would permit operators to reduce the number of craft in their fleets, and the low vibration level of the engine would reduce depreciation costs. The principal design and operational problems presented by this type of transport are summarized briefly.

Tests of an Adjustable-Area Exhaust Nozzle for Jet-Propulsion Engines. E. C. Wilcox. *U.S., N.A.C.A.., Memorandum Report No. E5H16 (Wartime Report No. E-265)*, August, 1945. 17 pp., illus., figs.

Jet Blow-Out. *Naval Aviation News (Reserve Edition)*, No. 12, April, 1948, pp. 30, 31, illus. Wind-tunnel tests conducted by the N.A.C.A. to determine the factors affecting jet-engine blowout determined the variation of critical compressor speed with altitude.

Tests of Air Valves for Intermittent-Jet Engines at Speeds of 20 and 25 Cycles Per Second. Joseph R. Bressman and Robert J. McCready. *U.S., N.A.C.A., Memorandum Report No. E5E08 (Wartime Report No. E-258)*, May, 1945. 23 pp., illus., figs.

Altitude-Wind-Tunnel Tests of Power-Plant Installation in Jet-Propelled Fighter. G. Merritt Preston, Fred. O. Black, Jr., and James M. Jagger. *U.S., N.A.C.A., Memorandum Report No. E5L17 (Wartime Report No. E-274)*, February, 1946. 32 pp., illus., figs. 2 references.

Canada Tests First Home-Built Jet Engine; 2590-lb. Thrust Unit Is Forerunner of Larger Engine to Power Avro Fighter Plane Now Being Constructed. *Aviation Week*, Vol. 48, No. 17, May 3, 1948, p. 17, illus.

Canada's First Jet Engine Avro Chinook Makes Debut. *Aircraft and Airport*, Vol. 10, No. 4, April, 1948, pp. 31, 32, illus.

Avro Chinook Success Marks Era in Aviation Industry. *Canadian Aviation*, Vol. 21, No. 5, May, 1948, pp. 28, 29, illus.

Jets in England. Myron Eddy. *Aero. Digest*, Vol. 56, No. 4, April, 1948, pp. 26–29, 104–106, illus., figs.

Brief notes on the British development of turbojet and turboprop power plants, and British compressor and combustion chamber design practice. Four charts tabulate the general specifications of 34 American and British turbojet and turboprop engines.

RECIPROCATING (6)

Survey of Power Plant Installation Troubles in Scheduled Air Carrier Operations. John W. Baird. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting, New York*, April 13–15, 1948. 14 pp., figs.

An analysis of data contained in the Mechanical Interruption in Flight Reports submitted to the C.A.A. by scheduled air carrier operators from 1937 to 1947, inclusive. The report excludes failures and defects of components that are integral parts of the engine and the propeller proper. The number of aircraft in operation each year, the annual aircraft revenue hours, and the average number of revenue hours per aircraft per year are expressed as curves. The number of troubles reported per 10,000 aircraft revenue hours, are given as percentages of an arbitrary base, the total for the period 1937 to 1939, inclusive, and are represented by bar graphs. Of the total failures, the lubrication system was responsible for 20 per cent, the fuel system for 18 per cent, and personnel for about 15 per cent. The controls accounted for about 14 per cent, accessories 11 per cent, instruments and the exhaust system 7 per cent each, the cooling system 6 per cent, and the induction system 1 per cent. A further detailed breakdown indicates components of the power-plant installation that are most in need of improved design.

Analysis of the Thermal Ignition Process in Internal Combustion Engines. V. P. Karpov. (*Avtomobil'naia Promyshlennost'*, No. 9, 1947, pp. 8–13.) *The Engineers' Digest*, Vol. 5, No. 3, March-April, 1948, pp. 149–151, figs.

A study of the reaction speed of a combustible mixture with respect to the temperature and pressure conditions in the combustion chamber show that time is required not only for the heating up of the mixture but also for the preignition decomposition process. A formula is obtained by which the critical pressure for preignition may be determined for different temperatures of the wall surface of the combustion chamber.

Master Control Fuel Injection System for Aircraft Engines. II. H. M. Hobson, Ltd. *The Technical Instructor*, Vol. 3, No. 4, April, 1948, pp. 3–10, diagrs.

Descriptions of two systems. The Hobson company developed the design of its injection carburetor, in which the fuel-metering system and boost control were combined in one unit, into a fuel injection control system in which the fuel-metering unit, the impeller, and boost-control unit were separate elements.

Direct Injection Developed for Large Aircraft Engine. J. T. Marshall. *S.A.E. Journal*, Vol. 56, No. 5, May, 1948, pp. 28, 29, fig. (Summary of a paper.)

Analysis of Spark-Ignition Engine Knock as Seen in Photographs Taken at 200,000 Frames a Second. Cearcy D. Miller, H. Lowell Olsen, Walter O. Logan, Jr., and Gordon E. Osterstrom. *U.S., N.A.C.A., Advance Restricted Report No. E6D23* (*Wartime Report No. E-239*), May, 1946. 23 pp., figs. 26 references.

Efficiency of a Radial-Flow Exhaust-Gas Turbosupercharger Turbine With a 12.75-Inch Tip Diameter. Earl E. Coulter, Robert G. Larkin, and David S. Gabriel. *U.S., N.A.C.A., Memorandum Report No. E6F03* (*Wartime Report No. E-281*), July, 1946. 28 pp., illus., figs. 6 references.

Effect of Fuel Volatility and Mixture Temperature on the Knocking Characteristics of a Liquid-Cooled Single-Cylinder Test Engine. Max J. Tauschek and A. F. Lietzke. *U.S., N.A.C.A., Memorandum Report No. E5D24* (*Wartime Report No. E-257*), April, 1945. 28 pp., diagrs., figs. 6 references.

The Effect of Modified Baffles and Auxiliary-Cooling Ducts on the Cooling of a Double-Row Radial Engine. Stanley L. Gendler and Robert M. Geisenheyner. *U.S., N.A.C.A., Memorandum Report No. E5C20* (*Wartime Report No. E-255*), March, 1945, 30 pp., illus., figs. 3 references.

Effect of NACA Injection Impeller and Ducted Head Baffles on Flight Cooling Performance of Double-Row Radial Engine in Four-Engine Heavy Bomber. Frank E. Marble, Mahlon A. Miller, and Joseph R. Vensel. *U.S., N.A.C.A., Memorandum Report No. E5D13* (*Wartime Report No. E-256*), April, 1945. 32 pp., illus., figs. 6 references.

Cooling of a Double-Row Radial Engine by Water Injection to the Individual Cylinders. Louis L. Monroe and Harold E. Friedman. *U.S., N.A.C.A., Memorandum Report No. E5B27* (*Wartime Report No. E-254*), February, 1945. 31 pp., illus., figs. 2 references.

Ancestor Worship in Engine Control Design. R. R. Higginbotham. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting, New York*, April 13–15, 1948. 22 pp., illus., diagrs.

A survey of eight aircraft manufacturers showed that while propeller, turbosupercharger, and most secondary power-plant controls are almost universally operated by nonmechanical remote positioning controls, mechanical controls are almost always used for throttle and mixture controls. If a light, reliable remote positioning system were available and acceptable to their customers all manufacturers of large aircraft would like to make all engine controls nonmechanical. A survey of two engine manufacturers and seven control manufacturers showed that electronic mixture and turbosupercharger controls are available in production and that six other nonmechanical systems are in various stages of test and development. The delay in adopting these improved controls is caused by the requirements of the Air Materiel Command which specify that, where a nonmechanical control is used for the throttle, an overriding mechanical control must be provided. However, the interest of the A.M.C. in the development of nonmechanical controls for both turbojet and reciprocating engines indicates the likelihood of this restriction being lifted.

ROCKET (4)

The Acid-Aniline Rocket Engine. W. P. Berggren, C. C. Ross, R. B. Young, and C. E. Hawk. *American Rocket Society, Journal*, No. 73, March, 1948, pp. 17–30. 8 references.

In two bipropellant rockets that have the same ratio of propellant volume to total volume, oxygen-gasoline fuel constitutes two-thirds of the gross weight, and acid-aniline constitutes three-fourths. If the volumes are equal the acid-aniline has a 24 per cent range advantage over the liquid oxygen-gasoline system. For a given gross weight the acid-aniline system has an 11 per cent range advantage and requires 21 per cent less volume. For a given range the acid-aniline system permits a 35 per cent reduction in volume and an 18 per cent reduction in gross weight. For either combination of propellants a pressurized fuel system may be used, but for an operation of more than a few seconds' duration a turborocket design imposes a lesser weight penalty. In the turborocket the fuel and oxidizer pumps are run by a turbine. This necessitates a fuel supply complicated by the addition of flow control or by-pass valves to stabilize the operation of the turbine, whether it is driven by the gaseous products of an independent chemical reaction or by the reaction of the rocket fuels in a special chamber.

The Design and Development of Rocket Engine Powerplants for Aircraft. Alfred K. Huse. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting*, New York, April 13–15, 1948. 6 pp., illus.

The principal problems encountered in the development of a rocket power plant are the design of the injector, the control of the fuel supply and its metering during starting and stopping, and the strength of the combustion chamber and nozzle. The progress that has been made in rocket development as reported in newspapers could be synthesized to indicate the probability in the near future of supersonic aircraft capable of 3,600 m.p.h. and developing 45,800 hp.

Rocket Power. Eric Burgess. *Aeronautics*, Vol. 18, No. 6, May, 1948, pp. 38–50, illus., diagrs., figs.

A general résumé of the basic design and operation of solid and liquid propellant rocket power plants. While solid fuel rockets have the advantage of simplicity of construction and operation and the propellant charge itself insulates the shell of the rocket from the heat of combustion, the applications of this type of rocket are limited by the low specific impulse of all known fuels, their susceptibility to deterioration during storage, and the critical effect of the configuration of the charge and its physical condition upon combustion characteristics. Liquid fuels require complicated fuel supply, metering, and mixing systems and introduce the problem of cooling the combustion chamber, but they have a flexibility that permits both the burning time and the thrust delivered to be controlled. The development of the regenerative cooling system in which the fuel is used as the coolant of the combustion chamber before its injection improved the thermal efficiency of the rocket by utilizing heat that would otherwise be dissipated and made the development of the modern rocket motor possible. The modified V-2 rocket and the Vickers rocket-powered guided missile are examples of the nonmilitary application of this type of power plant. Schematic diagrams and cutaway drawings illustrate the various types of fuel feed systems and typical rocket layouts.

The Mass-Ratio Problem. *American Rocket Society, Journal*, No. 73, March, 1948, pp. 37, 38, fig. An analysis of the effect of velocity increment and jet velocity on the mass ratio of rockets, showing the inherent restrictions placed on the initial mass of a rocket regardless of the source of energy used.

Metallurgical Aspects in the Design of Rocket Motors. J. N. Nutt. *American Rocket Society, Journal*, No. 73, March, 1948, pp. 31–34.

The operating conditions of rockets impose extremely high temperature, strength, and corrosion resistance requirements on their structural materials. These conditions are higher than those existing in the gas turbine but are of much shorter duration. In spite of their low strength, poor coefficient of heat transfer, and susceptibility to intergranular corrosion, the good temperature and corrosion characteristics of austenitic stainless steels have permitted their use in rockets, and techniques have been developed by which they may be satisfactorily welded and formed. Further development of rockets calls for the investigation of ceramics and porous metals. If lighter weight is to be achieved, light-metal alloys must be developed for this application.

Present and Future of Rockets. Dan A. Kimball. *American Rocket Society, Journal*, No. 73, March, 1948, pp. 9–16. 1 reference.

A summary of the problems met during the development of the original jet-assisted take-off motor of the Aerojet Engineering Corp., which delivered 28 lbs. of thrust for 12 sec., into a motor giving 1,000 lbs. of thrust for 5 sec. This development and parallel research on booster rockets and liquid-propellant rockets required the establishment of extensive facilities for testing and production control. At present, the restricted commercial application of rockets imposes upon the military the primary responsibility for their further development.

Patent Application on Improved Combustion for Rocket Engines. Wilhelm Schmidding. (*DRP-Anmeldung*, October, 1944.) *U.S., Air Force, Translation No. F-TS-2832-RE*, February 26, 1947. 2 pp.

Provides a series of combustion chambers arranged in tandem, in each of which additional oxidant is supplied to the unburnt fuel and the products of combustion. The arrangement increases the effective combustion time in jet engines that operate on solid, liquid, or gaseous fuels.

New Pyrometer Measures Rocket Exhaust Temperatures. *Product Engineering*, Vol. 19, No. 5, May, 1948, pp. 150, 151, illus., fig.

A pyrometer developed by the Aerophysics Laboratory of North American Aviation, Inc., is based on the equivalence of absorptivity and emissivity for gas flames. The light from a tungsten filament lamp is split into two beams. One beam passes through the flame by a system of mirrors. Two synchronized rotating shutters cause each beam alternately to excite a photoelectric cell. By adjusting the brightness of the lamp until the two beams are of equal brightness, the brightness temperature of the lamp will equal the true temperature of the flame, because at this value of lamp brightness the flame emits as much light as it absorbs.

Production (36)

Vampire Production; Manufacture of the de Havilland Jet Fighter by the English Electric Co., Ltd. I—Origin and Design; Fuselage Shell. S. C. Poulsen. *Aircraft Production*, Vol. 10, No. 115, May, 1948, pp. 154–161, illus., cutaway drawings.

Detailed descriptions of the fuselage, wing attachments, pickup fittings for local reinforcement of the shell, and the technique used to join the half-shell segments that comprise the fuselage. Local reinforcement of the shell is obtained with formed laminated members that are built into the balsa interlayer of the ply and balsa shell.

A Master Control System. John Savage. *Product Engineering*, Vol. 19, No. 5, May, 1948, pp. 109–112, figs.

In order to avoid the interference of equipment installations and structural elements and to provide a central source of design information, The Glenn L. Martin Company has set up a master design control system. Each proposed design element is represented by a white cardboard disc affixed to a quarter-scale photographic reproduction of the side elevation of the airplane. When the installation goes into active design, an IBM space reservation card is made out and a colored disc marked with the location of the item in three-dimensional coordinates is used on the master chart. From the IBM record possible interference is discovered and the designers concerned so notified. A final check is obtained by making master installation layouts and superimposing on them transparent reproductions of the corresponding lofts.

Stretch-Forming Skin Panels. H. J. Dowsett. *Aircraft Production*, Vol. 10, No. 115, May, 1948, pp. 177, 178, diagrs.

The shallow double-curvature fuselage panels used on the Handley Page Hastings military transport are sufficiently flexible to be deformed elastically without interfering with their original shape. They were manufactured by stretch forming so that they could be sprung when assembled in such a way that the increase in the radius of curvature on one axis increased the curvature on the other axis and automatically tightened it to fit. It was found necessary to devise a hand-operated shaping tool that worked on the strickle-board principle to give a sufficiently accurate surface to the antimony-lead stretching tool that was used.

The History of Canadair. *Aircraft and Airport*, Vol. 10, No. 4, April, 1948, pp. 22, 28, 50, illus.

Aircraft Manufacture in India. *Indian Aviation*, Vol. 32, No. 3, March, 1948, pp. 83, 84.

Flash Butt Welding; Experimental Spar-Bracing Tubes for the Bristol Type 167 Aircraft. I—The Structure: Exploratory Experiments. G. E. Nash, H. Brooks, and M. A. Garnett. *Aircraft Production*, Vol. 10, No. 115, May, 1948, pp. 167–171, illus., diagrs.

A tubular-steel construction was selected for the wing spar bracing in the vicinity of the buried engines of the Bristol Type 167 airplane. Flash butt-welded tubular units were originally chosen in preference to conventionally jointed tubular units, arc-welded heat-treated units, or a complete arc-welded structure, because of the low weight penalty it placed upon the design. The results of the tests conducted to determine the suitability of the method in this application are summarized.

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The Measurement of Secondary Current, Voltage and Electrode Load Cycles for Spot Welding Machines. G. E. Bennett and H. E. Dixon. *Institute of Welding, Transactions*, Vol. 11, No. 2 (*Welding Research*, Vol. 2, No. 2), April, 1948, pp. 26r–36r, illus., figs. 10 references.

Report of research conducted by the Instrumentation and Materials Departments of the Royal Aircraft Establishment in conjunction with the Philips Central Material Research Laboratories. The various pickup devices and amplification circuits are analyzed by which the electrode tip load, the secondary current, and the secondary voltage may be measured and their variation with time recorded. A three-channel cathode-ray-tube recorder and a drum type of camera were used to record simultaneously the individual effect and the interrelation of the variables affecting the secondary current and voltage during the operation of the Philips Experimental Type E1501 Spot Welding Machine. A similar record of the electrode load cycle is correlated with the pneumatic cycle of the spot-welding machine.

Eliminating Cracking in Magnesium Arc Welds. P. F. George. *Materials & Methods*, Vol. 27, No. 4, April, 1948, pp. 68–71, illus., figs. 9 references.

The presence of a pronounced network of the low-melting constituent of magnesium alloys between grain boundaries in areas adjacent to cracks in alloy welds indicated that the width of solidification range controlled the weld cracking tendency. Heating and quenching tests of FS-1 and M magnesium alloys and subsequent metallographic determination of the nonequilibrium solidus showed that calcium decreases the solidus to a remarkable extent in FS-1 alloy and to a lesser extent in the M alloy. Calcium, therefore, by increasing the width of the solidification range, increased the weld cracking. The cracking can be eliminated in M alloy by keeping the Ca content below 0.15 per cent and using an M alloy rod. In the FS-1 the effect of calcium is so marked that keeping its calcium content low is not sufficient to eliminate cracking under strained conditions completely. It is necessary also to use welding rods of a higher aluminum and zinc content such as J-1, O-1, or C alloy. Tables give the composition of magnesium alloys in order of their tendency to weld cracking and also of their liquidus and nonequilibrium solidus characteristics in the same order.

German Practice in Fabrication of Gas Turbine Blades. Joseph Robinson. *U.S., Field Information Agency, Technical, Final Report No. 1129*, June 13, 1947. 14 pp., illus., diagrs. 2 references. British Information Services, New York. $0.70.

The Bayrische Motoren Werke fabricated gas-turbine blades from an austenitic chromium-manganese steel by machine turning, deep drawing, and cold forming and welding. In both the machining and drawing process, a hollow tube is produced which is pressed to the desired profile. Instead of copper plating the blade between draws, a lubricant consisting of graphite, cornstarch, soap, and waterglass is used. Cold forming is done between dies with a mandril up the middle. Method of retaining blades in the rotor wheel and comparative production costs included.

Balancing Supercharger Rotors. H. S. Seekins. *The Tool Engineer*, Vol. 19, No. 6, January, 1948, pp. 25–29, illus., figs.

High-speed, lightweight superchargers required high accuracy in the balancing of the rotor-impeller assembly. The original air-driven balancing frame used by General Electric required grinding of the wheels by hand. The introduction of electrically operated dynamic balancing machines and their subsequent development reduced the labor production cost on each rotor by 91 per cent.

Application of Heat to Swaged Tungsten Permits Parts to be Machined. Dan White and J. J. Aust. *Materials & Methods*, Vol. 27, No. 4, April, 1948, p. 81, illus.

Swaged tungsten can be machined with a Carboloy No. 883 tool by heating the work piece in an oxyacetylene flame to about 1,300°F. A speed of 229 r.p.m. and a feed of 0.0031 in. per revolution should be used.

Commercial Possibilities of the Lost Wax Process. A. Short. *Aircraft Engineering*, Vol. 20, No. 230, April, 1948, pp. 105–108, illus.

Developments in the process are being directed toward improvement of the investment mixture, the substitution of water for the alcohol commonly used as a solvent, and the use of materials other than wax for the mold. An analysis of labor and material costs indicates that the process may be used economically when the material being cast is difficult to machine or fabricate or when delicacy and intricacy of shape must be combined with strength of material.

Drill Grinding. Harold C. Reading. *Aircraft Production*, Vol. 10, No. 115, May, 1948, pp. 172–174, illus., figs.

The matrix drill gage and its operation. A direct reading is given of the angles and lengths of the cutting edges. In addition to enabling the operator to check the relative angularity of the cutting edges and the centrality of the point during regrinding, a record can be made of the characteristics of a drill that has cut satisfactorily before grinding so that these features may be reproduced in regrinding.

Drawing Dies for Magnesium. James Walker. *The Tool Engineer*, Vol. 19, No. 6, January, 1948, pp. 31–35, illus., figs.

The design of dies and presses, clearance and radii, and lubricants. The susceptibility of magnesium at room temperature to cold working makes it necessary to operate dies at elevated temperatures.

K. M. Alloy Blanking and Press Bend Tools; Particulars of the Experiences of Percival Aircraft Ltd., of Luton, in the Use of Alloy Tools in the Production of Detail Parts. *Aircraft Engineering*, Vol. 20, No. 230, April, 1948, p. 116, illus.

Sub-Assembly Tooling; Use of Erco Fixtures and Riveting Machines by Consolidated Vultee. *Aircraft Production*, Vol. 10, No. 115, May, 1948, pp. 164–166, illus., diagrs.

In the production of the Convair-Liner an Erco assembly fixture that is built up from a full-scale template is used in the preassembly of the fuselage bulkhead and frame assembly and the fuselage skin-and-stringer panels. These fixtures and Erco automatic riveting machines afford a high degree of interchangeability without the use of unduly elaborate equipment.

Inexpensive Tooling. Arthur W. Morgan. *Aircraft Production*, Vol. 10, No. 115, May, 1948, pp. 149–152, figs.

A substantial reduction in production costs can be obtained by dispensing with tool-fixture drawings and employing instead a group of toolmakers capable of designing tools directly from the part drawing. The cost of tooling can be further reduced by simplifying the design of blanking and bending tools, drill jigs, and assembly fixtures.

Mirrors Simplify Precision Work. *Aviation Week*, Vol. 48, No. 16, April 19, 1948, pp. 22, 25, illus.

In addition to hand mirrors and periscopes for checking the formation of rivet heads in inaccessible places, the Boeing Airplane Company elaborate mirror systems are used to view shock waves in ram-jet research and for aligning the individual guns in the turrets of the B-50. An optical system similar to the aligning system is used to harmonize the three or four guns in the turret so that the central fire-control system will parallel electrically the mechanical system established by the individual aligning.

Propellers (11)

Investigation of Effectiveness of Air-Heating a Hollow Steel Propeller for Protection Against Icing. I—Unpartitioned Blades. Donald R. Mulholland and Porter J. Perkins. **II—50-Percent Partitioned Blades.** Porter J. Perkins and Donald R. Mulholland. **III—25-Percent Partitioned Blades.** Donald R. Mulholland and Porter J. Perkins. *U.S., N.A.C.A., Technical Notes Nos. 1586, 1587, 1588*, May, 1948. 51; 25; 23 pp., illus., diagrs., figs. 5, 3, 3 references.

I. Blade-surface temperatures and heated-air temperatures of an air-heated hollow steel unpartitioned propeller blade under icing conditions were determined in the N.A.C.A. icing-research tunnel at Cleveland. Adequate ice protection was obtained with 40,000 B.t.u. per hour per blade. At lower heating rates significant ice accretions formed on the leading edge of the blade. The chordwise distribution of heat was unsatisfactory because most of the available heat was dissipated well back of the leading edge on both the thrust and camber faces instead of at the leading edge. The heat-exchanger effectiveness of the blade was approximately 47 per cent.

II. Similar tests with propeller blades partitioned radially at 50 per cent chord to confine the heated air to the forward half of the blade showed that a heating rate of 26,000 B.t.u. per hour per blade was required. The chordwise distribution of the heat was again found to be unsatisfactory because much of the heat was dissipated well back of the leading edge. Although the heat-exchanger effectiveness was 9 per cent greater than that obtained with unpartitioned blades, a poor utilization of the available heat was still indicated.

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III. An icing investigation of an air-heated hollow steel propeller with blades radially partitioned at 25 per cent chord was conducted in the N.A.C.A. Cleveland icing research tunnel. Results showed that at 850 r.p.m. a heating rate of 7,000 B.t.u. per hour per blade provided adequate icing protection at 23°F. but not as low as 15°F. Surface temperatures indicated satisfactory chordwise distribution. The blade heat-exchanger effectiveness was found to be 77 per cent.

The Development of Electro-Thermal Propeller De-Icing. John L. Orr. *Canada, National Research Council, Aeronautical Laboratories, Quarterly Bulletin, Report No. ME 1947 (4)*, October 1–December 31, 1947, pp. 1–7, illus.

Description of a system that weighs 50 lbs. per propeller, which, for operating periods longer than 3 hours, offers a lower weight penalty than that incurred with an alcohol distribution system. The leading three-quarter chord of the propeller blade is covered with a boot made of a layer of superconductive rubber, which acts as a heating element, sandwiched between two layers of insulating rubber. Current is supplied to electrodes on either side of the blade from a lightweight hub generator mounted between the engine and the propeller which at 1,250 r.p.m. delivers 3,500 watts at 130 volts and 250 cycles per sec. During a period of 2 years one installation gave satisfactory service for 1,200 hours of operation without serious deterioration.

Effect of Ice and Heated-Air Deicing on the Aerodynamic Performance of Propellers. Blake W. Corxon, Jr. *Preprint, S.A.E. National Aeronautic and Air Transport Meeting, New York*, April 13–15, 1948. 15 pp., figs. 6 references.

A summary of wind-tunnel investigations to determine the effect of ice on the aerodynamic efficiency of a propeller and the loss in aerodynamic efficiency caused by an idealized heated-air anti-icing system. A moderate accretion of ice on a propeller resulted in an efficiency loss of about 3 per cent for operation in cruise or gentle climb. In a steep climb this loss was probably 15 per cent or more and the propeller was subject to premature stalling. A heated-air thermal anti-icing system operated continuously produced a loss of about 1 per cent in aerodynamic efficiency, half of which was caused by the drag of the nozzles at the blade tips and the remainder by the internal airflow. Large changes in temperature of the internal airflow produced only a negligible change in propeller efficiency. An analysis indicated that, by reducing the exit nozzle area to an absolute minimum and by providing an aerodynamically clean internal flow system and exit nozzle installation, the aerodynamic efficiency loss caused by the heating system can be made imperceptible.

Hamilton Standard's Hollow Steel Blade. *The Bee-Hive*, Vol. 22, No. 2, Spring, 1948, pp. 18–23, illus., figs.

A history of the development of hollow propeller blades and a description of the principal manufacturing steps. Hollow blades permit a constant ratio to be maintained between the weight of the propeller and the horsepower of the engine. They permit greater flexibility in design than solid or machined-forging blades. Electric deicing elements can be installed inside the blade, and the stiffness factor of the blade is independent of its weight.

Airscrew Testing. Flight, Vol. 53, No. 2051, April 15, 1948, pp. 411–414, illus.

The test schedule and the rigs used by Rotol, Ltd., and the Royal Aeronautical Establishment to test and inspect propeller, hub, and spinner designs in fulfillment of the requirements of the Ministry of Supply and the Air Registration Board.

Reference & Bibliography*

Subject Headings for Index of NACA Publications. *U.S., N.A.C.A.*, September, 1947. 31 pp.

The subject headings being used for the index of N.A.C.A. publications are grouped under eleven main subjects: aerodynamics, hydrodynamics, propulsion, structures, materials, meteorology, operating problems, instruments, research equipments, research equipment, nomenclature, bibliographies, and indexes. Aerodynamics contains 375 individual subheadings, and it is by far the largest group. Here the breakdown within the subject proceeds from the abstract to the concrete. The major aircraft components are used as secondary headings and are further subdivided into elements, modifications, and complete structures. Subjects that do not possess a similar internal consistency are broken down arbitrarily—for example, Operating Problems: safety, navigation, ice, noise, heating and ventilation, lightning hazards, piloting technique, and physiological. To each subject heading, in addition to a decimal number, is assigned a Standard Subject Heading Title, to permit the establishment of an alphabetical subject index. The title emphasizes the particular subject rather than the position of the subject in the scheme.

Rotating Wing Aircraft (34)

The Helicopter Control Rotor. I. Joseph Stuart, III. *Aeronautical Engineering Review*, Vol. 7, No. 8, August, 1948, pp. 33–37, illus., figs. 5 references.

The Hiller control rotor slows down the following rates of the main lifting rotor of a helicopter and increases the damping in steady rolling or pitching motions. By direct linkage an overhead control stick gives cyclic pitch to the low aspect-ratio blades of a small control rotor mounted on the main rotor head. The aerodynamic effects of these blades act on the main lifting blades to determine their cyclic pitch. The desired following rate and damping can be obtained by proper blade design, and maximum rate of roll or pitch can be obtained by multiplying the maximum control input from the control stick. The absence of mechanical linkage between the control stick and the lifting blades insulates it from the roughness originating in the deflections and loadings of the large blades. A stability analysis of the free oscillations with fixed control of a conventional and a control-rotor configuration shows that the slow motions are made stable and their periods lengthened. The excessive response sensitivities in roll have been remedied and substantially equalized with those in pitch, and the fast motions remain stable but are less highly damped than in the conventional helicopter.

The Testing of Rotors for Fatigue Life. Jonathan Winson. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 392–402, figs. 6 references.

Fatigue stresses that well approximate those met in flight can be induced in articulated rotor blades by applying specified second harmonic control to a rotor revolving on a stationary whirl stand. The equations that are derived for the test parameters permit a general set of flight fatigue stresses to be duplicated. The test specification for a sample rotor is calculated.

New Ideas in Helicopter Control. Alexander Klemin. *Aero Digest*, Vol. 56, No. 4, April, 1948, pp. 51, 52, 102–104, illus.

Description and summary specifications of the Hiller 360. Cyclic control is accomplished by direct manual variation of the pitch of the servo-rotor blades. The aerodynamic moment caused by their changed plane of rotation causes the rotor to tilt until the plane of the lifting blades is parallel to the plane of the swash plate that controls the servo-blades.

Coordinating Helicopter Pitch and Power. A. F. Donovan and Harold Hirsch. *S.A.E. Journal*, Vol. 56, No. 4, April, 1948, pp. 63–68, figs. (Extended summary of a paper.)

A control system that linearizes both the pitch-torque requirement and the torque-throttle setting relationships of a helicopter and permits the linking of the pitch control system and the throttle setting to one control lever. A dead-center pitch system uses a bellcrank in the pitch system to linearize the parabolic pitch-torque relation of the rotor. A cam appropriate for each power plant linearizes the torque throttle relation. The pilot's increased mechanical advantage at large pitch angles would make it possible to reduce or eliminate the collective pitch bungee required by most helicopters. The increased motion of the pitch handle per degree change in rotor pitch at high angles enables the pilot to adjust to the desired pitch more easily.

Jet Blades Tested in Outdoor Pit. *Aviation Week*, Vol. 48, No. 17, May 3, 1948, p. 18, illus.

The Thermal Power Systems Division of the General Electric Company has constructed a bowl-shaped test pit, 150 ft. in diameter and 13 ft. deep, at Schenectady County Airport. A whirling rig in the center of the pit will be used to test designs for jet-powered helicopter rotor blades.

Testing Helicopter Drives. Miller A. Wachs. *S.A.E. Journal*, Vol. 56, No. 5, May, 1948, pp. 48–51, fig. (Extended summary of a paper: Accelerated Testing of Helicopter Drive Mechanisms.)

Production Preliminaries; Preparations for Manufacture of Westland-Sikorsky S-51 Helicopter. *Aircraft Production*, Vol. 10, No. 115, May, 1948, pp. 175, 176, illus., fig.

The substitution of British materials and accessories for the American items specified in the drawings of the Sikorsky S-51 helicopter that were supplied to the Westland Aircraft, Ltd., necessitated the issue of extract sheets detailing the modification. The principal difficulty in preparing the helicopter design for

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British manufacture arose not in translating the drawings but in determining the British equivalent for specialist-made products that are designated by different standards in the two countries.

The (Sznycer-Gottlieb) Mark VI-D Helicopter. *Flight*, Vol. 53, No. 2051, April 15, 1948, pp. 420, 421, illus.

The Nord 1700 Norelic; French Helicopter With Unusual Features. *Flight*, Vol. 53, No. 2050, April 8, 1948, p. 393, illus.

A prototype, the Nord 1700 Norelic, developed by S.N.C.A. du Nord, is a helicopter with a single two-bladed main rotor and a small auxiliary rotor. The auxiliary rotor is a pusher propeller running in a guide cowling or shroud. It provides some forward propulsion and counteracts torque reaction by the effect of its airflow on a series of large tail fins attached to the shroud.

The Los Angeles Helicopter Service. Alexander Klemin. *Aero Digest*, Vol. 56, No. 5, May, 1948, pp. 51, 52, 121, 122, illus. Summary of the historical background of the helicopter mail service conducted by Los Angeles Airways, Inc., and abstract of the maintenance, financial, and operations report of 4 months' activity.

Sciences, General (33)

MATHEMATICS

The Distribution of the Roots of a Complex Polynomial Equation. J. Williams. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2238*, January, 1946. 9 pp. 13 references. British Information Services, New York. $0.70.

An extension of the work of Routh and Hurwitz on the distribution of the roots of a polynomial equation with complex (or real) coefficients by which may be determined the roots that lie on any infinite radius through the origin of the complex plane and the number of roots that lie within a sector bounded by two such radii. The scheme suggested for the computation of the finite sequencies of polynomials corresponding to points on the two radial boundaries that must be determined is illustrated by a numerical example.

MECHANICS

Friction of Solid Films on Steel at High Sliding Velocities, Robert L. Johnson, Douglas Godfrey, and Edmond E. Bisson. *U.S., N.A.C.A., Technical Note No. 1578*, April, 1948. 65 pp., illus., figs. 19 references.

Kinetic friction experiments were conducted on steel specimens with thin inorganic solid films over ranges of sliding velocities between 50 and 8,000 ft. per min. and loads from 169 to 1,543 Gm. (initial Hertz stress 108,000 to 225,000 lbs. per sq.in.). MoS_2 was effective in reducing friction, was tenacious, was chemically and thermally stable, and consequently should have many applications. Fe_3O_4 was beneficial on run surfaces, whereas α-Fe_2O_3 was not. With films of type formed by extreme pressure lubricant additives, $FeCl_2$ was more effective in reducing friction than FeS.

OPTICS

Methods of Measuring Scattered Light at Optical Boundary Surfaces. P. H. Keck. *U.S., Field Information Agency, Technical, Final Report No. 780*, May 20, 1947. 62 pp., diagrs. 17 references. British Information Services, New York. $1.20.

An exposition of the geometric-optic relationships that govern the scattering of light at the boundary between two light transmitting mediums. The current methods used to measure this scatter are examined critically, and a design is proposed for a spherical scattered light meter operating on the shadow principle. The sensitivity of the instrument as illustrated in its application to plane plates, lens systems, and optical apparatus is sufficient to establish a new standard for the exact measurement of glass polish.

PHYSICS

Measurement of Water in Gases by Electrical Conduction in a Film of Hygrosocopic Material and the Use of Pressure Changes in Calibration. Elmer R. Weaver and Ralph Riley. *U.S., National Bureau of Standards, Journal of Research*, Vol. 40, No. 3, March, 1948, pp. 169–214, figs. 7 references. Available also as *Research Paper No. RP1865*, U.S. Govt. Printing Office, Washington, $0.25.

The electrical conductivity of a thin film of such a material as phosphoric acid changes over a wide range with changes in the concentration of water in the atmosphere with which it is in contact. By adjusting the pressures of sample of gas of known and one of unknown composition, they can be made to have the same concentration of water, shown by the production of equal resistances of the detecting film. Apparatus and procedures for making such adjustments and calculating analyses and applications are described. The method has the merits of simplicity, speed, and great sensitivity. Only small samples are needed, and few substances interfere.

Stress Analysis & Structures (7)

The Stressing of Large Rectangular Cut-Outs in Fuselages—Strain-Gauge Analysis of York. W. Kay and F. Micklethwaite. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2135*, March, 1945. 24 pp., figs., diagrs. British Information Services, New York. $1.45.

A general analysis of the stresses occurring near a large cutout in the side of a monocoque fuselage which gives approximate agreement with strain-gage readings taken on a York fuselage under load. Members along the upper and lower edges of the cutout should be designed as beams to resist bending in the plane of the sheet and the plane through the member normal to the sheet. The flanges that form the edges of the cutout should have sufficient area to prevent excessive direct stresses. These stresses are evaluated with sufficient accuracy for the fuselages of nearly rectangular cross section, with well-defined coaming members, by dividing the superposed load by the area of the flange plus the area of a panel extending to a distance one-eighth the length of the cutout from the edge. The bending of a rectangular fuselage is in the plane of the side, and the stresses are determined by considering the side containing the cutout to react all the superposed loads. The proportion of bending and shear reacted by the structures above and below the cutout is determined by their relative stiffness.

Stress Concentration Around an Ellipsoidal Cavity. M. A. Sadowsky and E. Sternberg. **Discussion.** L. H. Donnell and R. E. Peterson. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 87, 88, figs. 3 references.

Large Displacements With Small Strains in Load Structures. K. H. Swainger. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 45–48, figs. 14 references.

An exact solution for that class of problems in which the displacements of a flexible structure are large but the strains are small and the displacements can be predicted closely from the physical conditions imposed. The major component of the deflection is known. Polar coordinates are selected that have their origin in the strained body, and the remaining displacement necessary to produce compatibility is expressed as a plane polar coordinate problem. The method is applied to the generation of an elastic cylinder from a flat plate.

The Effect of Shape and Size Factors on the Fatigue Strength. N. N. Afanasev. (*A Collection of Papers on the Dynamic Strength of Machine Parts, Academy of Sciences of the U.S.S.R., Institute of Practical Engineering*, 1946, pp. 157–167.) *The Engineers' Digest*, Vol. 5, No. 3, March–April, 1948, pp. 132–136, figs. 20 references.

An empirical relation exists between the fatigue limit and the relative stress gradient to which the specimen is subjected. In cases where it is possible to determine the stress gradient and the theoretical stress concentration factor by this theory, it is possible to ascertain the properties of a material by a small series of fatigue tests from which further calculations may be carried out. The equation is suitable for finding the effective stress concentration factor in bending or tensile stressing. Analogous equations for other forms of loading could be derived from the same fundamental principles.

The Effect of End Constraint on Thin-Walled Cylinders Subject to Torque. M. Fine. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2223*, May, 1945. 15 pp., figs. 5 references. British Information Services, New York. $1.00.

The stresses arising because of end constraint at any point in a thin-walled cylinder of arbitrary cross section subjected to torque are assumed to be proportional to the longitudinal displacement of the point in an unconstrained cylinder. Since these stresses are self-equilibrating, the three constants expressing them may be

determined to give their distribution. This distribution is assumed to be the same at all sections of the cylinder, but its magnitude is assumed to decay exponentially along the cylinder. The magnitude of the stresses at the root may be found by strain-energy methods. Since the decay factor depends on the ratio of a generalized shear stiffness to a similar tensile stiffness, it will not be changed materially by a redistribution of the stress-bearing area, provided that the change is not too radical. Therefore an approximation of the decay factor can be obtained with less labor if the section is replaced by a doubly symmetrical rectangular section that encloses the area and for which total skin, stringer, and flange area is unchanged.

Effect of Bending Rigidity of Stringers Upon Stress Distribution in Reinforced Monocoque Cylinder Under Concentrated Transverse Loads. Robert S. Levy. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 30–36, illus., figs. 2 references.

Least-work analysis of stress distribution in a reinforced circular monocoque cylinder is extended to determine the effect of bending resistant stringers located at the points of application of concentrated transverse loads. Calculations for a numerical example, with applied loads diametrically opposed, indicate that neglect of stringer bending rigidity results in calculated maximum shear stresses approximately 20 per cent conservative in the fields of load application and 50 per cent unsafe in an intermediate field. Further calculations indicate that the bending rigidity of the stringer has less effect when all loads are applied at the same circumferential location. Comparison of shear stresses calculated by the present method with strain-rosette readings indicate good agreement.

An Evaluation of Some Approximate Methods of Computing Landing Stresses in Aircraft. Elbridge Z. Stowell, John C. Houbolt, and S. B. Batdorf. *U.S., N.A.C.A., Technical Note No. 1584*, May, 1948. 32 pp., figs. 4 references.

The landing of a simplified airplane structure, consisting of a uniform beam for the wings, a concentrated mass for the fuselage, and a linear spring for the landing gear, is analyzed exactly and is compared with several approximate solutions. The approximate solutions, which neglect elasticity in the determination of landing-gear reaction but consider elasticity in computations of stresses, give results of good accuracy and indicate that drop tests in which rigid masses are used may be a satisfactory approach to the landing problem.

Landing Impact Vibration Studied. *Aviation Week*, Vol. 48, No. 16, April 26, 1948, pp. 26, 27, diagrs. 1 reference. Studies at the National Bureau of Standards.

Camptograms for Beams in Compression. V. Rojansky and R. A. Beth. **Discussion.** H. Poritsky and M. C. Yovits. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 85, 86, figs. 3 references.

The Treatment of Continuous Beams by the Moment Distribution Method. D. A. C. Nicholls. *Aircraft Engineering*, Vol. 20, No. 230, April, 1948, pp. 109–111, figs.

A method introduced by Hardy Cross which is easier to handle than the theorem of three moments for the solution of continuous beam problems. A good approximation of the bending moments at the supports can be obtained during the early stages of the work, and the direction of these moments is clearly indicated. Each span of the beam is treated independently as though it were encastré. It is assumed, therefore, that each span has zero slope at the points of support and that the end moments depend entirely on the loading and the span. Since the moments occurring at the supports have two different values, the joint is out of balance by a known amount. Each joint is released by applying a moment of equal magnitude but opposite sign to that of the out-of-balance moment so that eventually the beam takes up its correct position.

A Note on Transverse Bending of Beams Having Both Translating and Rotating Mass Elements. R. H. Scanlan. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 425, 426, 434.

Equations for the transverse vibration of beams of variable mass and section, the structural characteristics of which are approximated by a matrix of deflection, influence coefficients at a finite set of points and require that not only the translation of the distributed mass be taken into account but also its rotation. The usual equations of transverse vibration of beams are extended to include effects of inertia elements in the beam which rotate, as well as translate, during transverse vibration of the beam.

Torsion-Bending Stresses in Box Beams. Robert A. Williamson. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 427–434, figs. 7 references.

A method of successive corrections which does not involve simultaneous equations is used to determine the bending stresses due to torsion in a prismatic box beam of rectangular cross section. The method, which is similar to the moment distribution method of Cross widely used in the analysis of continuous frames, can deal with cases that involve flexible bulkheads and complete cutouts of one or both surfaces. The expressions that are given for constants are analogous to the fixed end moments, stiffness, carry-over, and rigidity factors of moment distribution.

The Flutter of a Uniform Wing With Tip Weights. Martin Goland and Y. L. Luke. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 13–20. 6 references.

The differential equations for the motion of a wing in free flight are solved for a flutter system consisting of a wing carrying a fuselage at its semispan and a weight at each wing tip. The solution is considerably simplified by using a convergent power series in the determination of the boundary constants. A comparison of the results obtained for two representative airplane configurations with those obtained by the conventional Rayleigh type of flutter analysis shows that under certain circumstances the dynamic assumptions inherent in the Rayleigh analysis can lead to appreciable error in the magnitude of the predicted flutter speed. The Rayleigh flutter analysis in two degrees of freedom predicts wing performance only approximately. No simple means is available for determining the direction of the error. Both predicted critical speeds and predicted frequencies may be either lower or higher than the true values. The shape of the wing flutter mode predicted by the Rayleigh analysis, unless reinforced by many degrees, is not generally accurate. In the systems treated, the tip motion was predicted reasonably well but the mode shape inboard was considerably distorted.

The Rolling Power of an Elastic Wing. I—Compressibility Effects Absent. A. R. Collar and E. G. Broadbent. **II—Compressibility Effects and Results for Supersonic Speeds.** E. G. Broadbent and A. R. Collar. *Gt. Brit. Aeronautical Research Council, Reports and Memoranda No. 2186*, October, 1945. 37 pp., figs., tables. 19 references. British Information Services, New York. $2.05.

I. An iteration process for the determination of the rolling power at any forward speed of an elastic wing-aileron combination. A comparison of results with flight-test data and with an exact theoretical solution shows that the process gives results with an accuracy dependent on the accuracy of the aerodynamic and elastic data used. It gives better accuracy than the semirigid approach and is particularly suitable where unusual distributions of air force or elasticity cast doubt on the suitability of a conventional semirigid representation.

II. The method is extended by assuming that the aerodynamic coefficients are functions of Mach Number and that their variation is continuous but otherwise arbitrary. The method is especially simple when the variation is assumed to follow the Glauert law in the subsonic range and the Ackeret-Collar law in the supersonic range. Comparison with flight-test data shows good agreement up to about Mach 0.8. There will be a considerable drop in rolling power through the sonic region even though the wing is very stiff; there will be a slight recovery of rolling power as the speed increases into the supersonic region, but the rolling power remains relatively small. For a less stiff wing there may not be positive control above a Mach Number just less than unity. A discussion of the convergence of the process as a matrix interation is included.

Vibration of a Nonlinear System During Acceleration Through Resonance. R. B. Meuser and E. E. Weibel. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 21–24, illus., figs. 4 references.

A generalized solution obtained on the mechanical analyzer for the response of a single-degree-of-freedom system having linear plus cubic elasticity and linear or viscous damping when subjected to a sinusoidally varying exciting force of constant amplitude and of uniformly increasing frequency. This type of exciting force is representative of the various harmonic components of the gas pressure torque of an accelerated reciprocating machine. The amplitude of vibration is reduced by the addition of a cubic component, except under conditions of extremely small damping and slow rates of acceleration, when the addition of a moderate cubic component actually results in an increase in amplitude. Since

the addition of a cubic component can result only in an increase in the force transmitted in the range of variables considered and since in some cases the transmitted force is several hundred times the applied force, the introduction of nonlinear elasticity into systems that are accelerated through a critical speed may have either desirable or undesirable effects depending upon whether the maximum displacement or stress is limiting.

Vibration of a Beam With Concentrated Mass, Spring, and Dashpot. Dana Young. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 65–72, figs. 11 references.

An analytical method is developed for determining the natural frequencies of a composite system which consists of a uniform beam with a concentrated mass, spring, and dashpot attached at any point along the length of the beam. The method makes use of a series expansion in terms of the set of orthogonal functions that represent the normal modes of vibration of the beam alone. Numerical examples are given for a beam with a combined concentrated mass and spring, for a beam with two concentrated masses, and for a beam with an attached dashpot.

A New Fatigue Strength-Damping Criterion for Design of Resonant Members. Discussion. Joseph Marin and F. B. Stulen. Robert Plunkett, J. M. Robertson, and Alex Yorgiadis. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 83–85, fig. 5 references.

Finite Deflections of Sandwich Plates. Eric Reissner. *Journal of the Aeronautical Sciences*, Vol. 15, No. 7, July, 1948, pp. 435–440, fig. 2 references.

A system of differential equations for the small finite deflections of sandwich plates that consist of a core layer and two face layers of such construction that the face-parallel stresses in the core and the variation of the face stresses over the thickness of the face layers are negligible. The system is a generalization of the results for homogeneous plates where the problem can be reduced to two simultaneous equations for the transverse deflection of the middle surface and for an Airy stress function. It permits the analysis of the effects of transverse shear stress deformation and transverse normal stress deformation in the core on the overall behavior of the plate. In general, the effect of the transverse normal stresses in the core is negligibly small compared with the effect of the transverse shear stresses. When the equations are simplified by the omission of the transverse normal stress terms, their form becomes suitable for the solution of rectangular-plate problems. The range of deflections in which the linear ("small deflection") theory remains adequate decreases according to a simple explicit formula as the core is made softer relative to the faces. From this system of finite deflection equations, plate-buckling equations are obtained which include the effect of transverse shear stress deformation on the buckling loads.

Buckling in Shear of Continuous Flat Plates. Bernard Budiansky, Robert W. Connor, and Manuel Stein. *U.S., N.A.C.A., Technical Note No. 1565*, April, 1948. 24 pp., figs. 8 references.

The Langrangian multiplier method is used to calculate the theoretical shear buckling stress for an infinitely long, clamped plate that is divided into square bays at intermediate rigid supports and to determine the effect of plate continuity on shear buckling stresses for a plate of infinite length and width having intermediate rigid supports that form an array of square panels. The common assumption that continuous plates having equal, finite bays buckle in shear as if each bay were simply supported at the intermediate supports is an error. The increase in buckling stress due to continuity at the supported edges of square panels is of the order of 25 per cent of the increase that would be provided by clamping the edges. This continuity is probably a maximum for nearly square panels.

The Solution of Small Displacement, Stability or Vibration Problems Concerning a Flat Rectangular Panel When the Edges Are Either Clamped or Simply Supported. H. G. Hopkins. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2234*, June, 1945. 18 pp., tables. 11 references. British Information Services, New York. $1.15.

The energy method for the exact solution of problems concerning the small displacements, stability, or vibration of a flat rectangular panel when the edges are either clamped or simply supported. The influence of stiffeners parallel to one pair of edges and situated in pairs on opposite sides of the panel so that the neutral axis of each stiffener pair lies in the middle surface of the panel is taken into account. The method is applicable to aeolotropic panels when the material of the panel has two directions of elastic symmetry parallel to the edges. The final solution of the problems depends on an infinite set of linear equations for small displacement problems or on an infinite determinantal equation for stability and vibration problems. Since, in general, it is not possible to obtain a direct solution of the final equations, it is necessary to approximate and consider a finite set of linear equations or a finite determinantal equation derived from the more important terms in the analytical expression for the transverse displacement of the panel. The accuracy of the result is gaged by the rate of convergence with the increase in the number of terms considered.

A General Small-Deflection Theory for Flat Sandwich Plates. Charles Libove and S. B. Batdorf. *U.S., N.A.C.A., Technical Note No. 1526*, April, 1948. 53 pp., diagrs. 11 references.

A theory taking into account deflections due to shear. Seven physical constants must be known: two of flexural stiffnesses, two of shear stiffnesses, a twisting stiffness constant, and two Poisson ratios defined in terms of curvature. These can be evaluated theoretically from the materials used or they may be obtained from simple tests on samples of the assembled sandwich. In a set of six differential equations, three express the equilibrium of an infinitesimal plate element, and three relate the curvatures and twist of the element to the forces and moments acting upon it. A further expression is given for the total potential energy of the system comprising the plate and the forces acting upon it. The six differential equations involve six variables but can be reduced to a single equation of sixth order containing any one of the variables alone. A variational method is used to show the consistency between the differential equations and the potential energy expression, and boundary conditions more general than freedom, simple support, or clamping are taken into consideration.

Critical Shear Stress of Plates Above the Proportional Limit. George Gerard. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 1–12, illus., figs. 4 references.

A series of tests were made with panels of aluminum alloy 24S-O in which it was shown that the ratio of the secant shear modulus to the elastic shear modulus served as a satisfactory material constant in the critical-shear-stress equations for theoretical calculation of shear instability above the proportional limit of the material. The applicability of the secant modulus in shear instability and its similar validity in compression studies suggest that a re-examination of fundamental plate-instability theory might permit its extension into the inelastic range.

Square Plates Fixed at Points. C. J. Thorne. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 73–79, figs. 14 references.

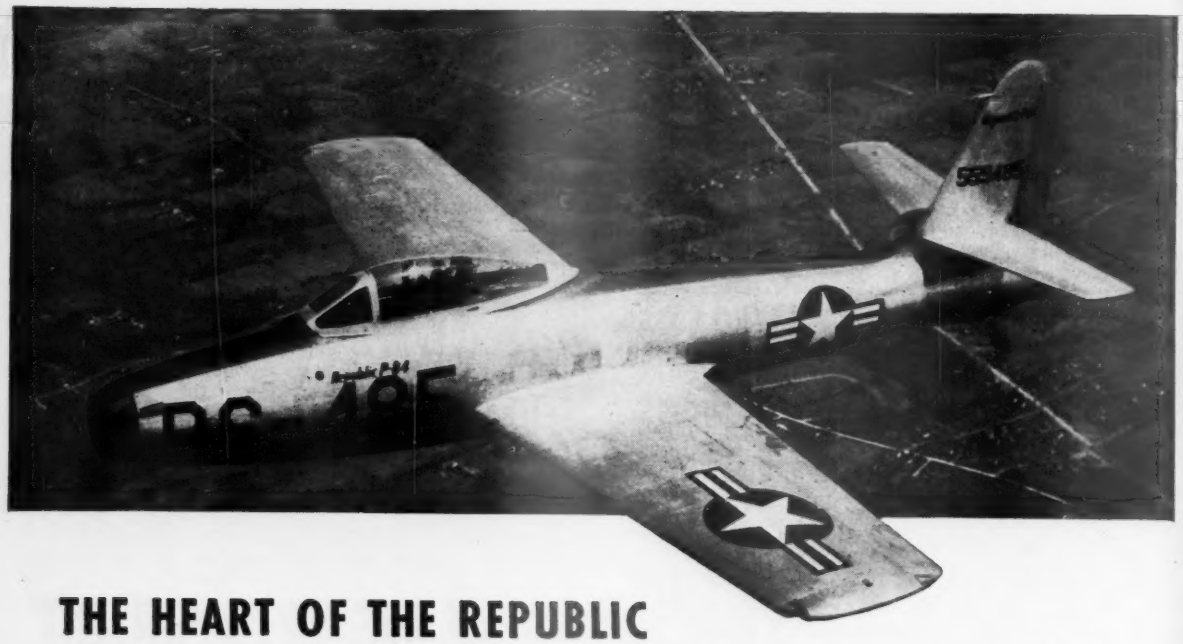
Deflection functions for thin plates with symmetric loads are given as a sum of biharmonic polynominals with coefficients determined by the slopes and deflections at five equally spaced points on each edge of the plate. The coefficients are given numerically for a point load and a uniform load, for zero slope and deflection at the five points, for the tangential slope at two of the five points not specified, for a particular slope, and for a particular deflection at the midpoints of the edges. Deflections are plotted at the edges, the center line, and the diagonal. Slopes are plotted at the edges. Moments and stresses are given at the midpoint of the edges.

The Bending of Symmetrically Loaded Circular Plates of Variable Thickness. H. D. Conway. *Journal of Applied Mechanics*, Vol. 15, No. 1, March, 1948, pp. 1–6, figs. 5 references.

The purpose of the investigation was to obtain a solution to the problem of a symmetrically loaded circular plate with a central hole, with the thickness of the plate at any section proportional to the distance of the section from center of the plate. Six particular cases were investigated, and the values of the maximum stress and deflection calculated for various ratios of the external diameter of the plate to the diameter of the central hole. These values are compared with the corresponding values obtained for plates of constant thickness by A. M. Wahl and G. Lobo.

Large Deflection of a Circular Clamped Plate Under Uniform Pressure. Wei-Zang Chien. *Chinese Journal of Physics*, Vol. 7, No. 2, December, 1947, pp. 102–113, diagrs. 12 references.

The problem of the large deflection of a clamped circular plate under uniform pressure is studied by the method of successive approximation in terms of the parameter representing the ratio of the center deflection to the thickness. The tedious numerical computations involved in Way's power series solution are thus avoided. The yielding condition at the edge checks very well with the experimental results given by McPherson, Ramberg, and



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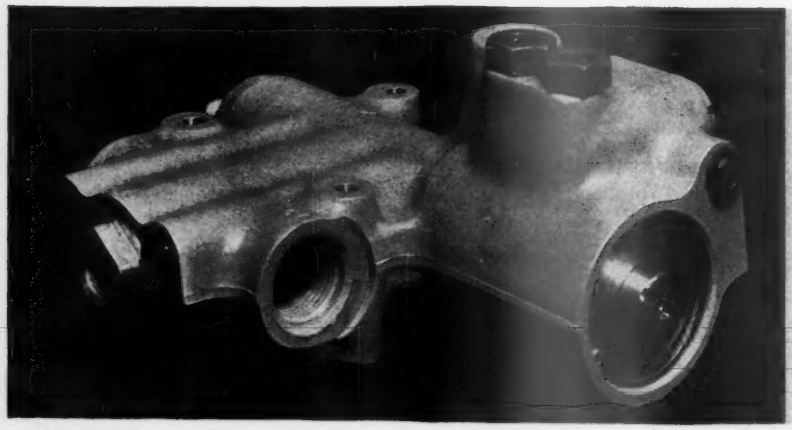

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Levy. The method may be easily extended to any other boundary conditions and loading details.

Buckling Stresses of Clamped Rectangular Flat Plates in Shear. Bernard Budiansky and Robert W. Connor. *U.S., N.A.C.A., Technical Note No. 1559*, May, 1948. 11 pp., figs., table. 6 references.

By consideration of antisymmetrical, as well as symmetrical, buckling configurations, the theoretical shear buckling stresses of clamped rectangular flat plates are evaluated more correctly than in previous work. The results, which represent the average of upper- and lower-limit solutions obtained by the Langrangian multiplier method, are within 1¼ per cent of the true buckling stresses.

Methods of Constructing Charts for Adjusting Test Results for the Compressive Strength of Plates for Differences in Material Properties. George J. Heimerl. *U.S., N.A.C.A., Technical Note No. 1564*, April, 1948. 14 pp., figs. 5 references.

Because the materials specified in aircraft design differ in compressive strength from the material used for the test of structural elements, plate test results must be adjusted before they are used in design. A method is given, based on the stress-strain curve of the material and its secant modulus of elasticity, by which charts may be constructed which give the necessary adjustment to standard values of the critical compressive stress, and the average compressive stress at maximum load. Illustrative charts for extruded 24S-T and 75S-T aluminum alloys included.

Compressive Buckling of Simply Supported Plates With Transverse Stiffeners. Bernard Budiansky and Paul Seide. *U.S., N.A.C.A., Technical Note No. 1557*, April, 1948. 20 pp., figs. 5 references.

The Rayleigh-Ritz method is used to obtain stability criteria for the compressive buckling of a simply supported plate that has, in addition to identical equally spaced intermediate stiffeners, end stiffeners of half the torsional rigidity of the intermediate stiffeners. The criteria are obtained in series form and are reduced to closed form to facilitate the derivation of limiting stability criteria for infinitely long plates with identical equally spaced stiffeners. The nondimensional curves that are plotted may be used directly to analyze the stability of transversely stiffened plates. The charts cover the practical range of stiffener spacings between zero to one-half the plate width.

Note on the Thermal Stresses in a Long Circular Cylinder of $m + 1$ Concentric Materials. B. E. Gatewood. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 84–86. 1 reference. A method of setting up and solving a system of equations for the analytic functions of the stresses in each of concentric cylinders.

The Method of the Hypercircle in Elasticity When Body Forces are Present. J. L. Synge. *Quarterly of Applied Mathematics*, Vol. 6, No. 1, April, 1948, pp. 15–19. 2 references.

In a former paper by the author, the method of the hypercircle in function space for boundary value problems in elasticity was developed under the restriction that body forces were absent. In this note these restrictions are removed and the method is presented in complete form. The natural state of stress throughout a body is assumed to correspond to a vector in function space. The extremity of this vector lies on a hypersphere determined by the basic stress state and the basic displacement state of the body. Since the states determining the sphere belong to the classes of basic stress states and basic displacement states, the set of homogeneous stress vectors is orthogonal to the set of homogeneous displacement vectors. It can be shown then that the extremity of the natural vector representing the natural stress state is located on a hypercircle. From the expressions for the position vectors for the point on the circle which is farthest from the origin of function space and for the point nearest to the origin, a set of inequalities is obtained for the magnitude of the vector that corresponds to the natural state of the elastic body. These inequalities bound the strain energy of the natural state below and above.

Effect of Variables in Welding Technique on the Strength of Direct-Current Metal-Arc-Welded Joints in Aircraft Steel. II—Repeated-Stress Tests of Joints in SAE 4130 Seamless Steel Tubing. C. B. Voldrich and E. T. Armstrong. *U.S., N.A.C.A., Technical Note No. 1262*, April, 1948. 85 pp., illus., diagrs. 3 references.

Tests were made to establish the effect of electrode type, welding speed, current, position, preheat, and other factors that help control the weld contour, penetration, and depth of the heat-affected zone on the fatigue strength of arc-welded joints in SAE 4130 steel tubing. Stress concentrations caused by weld geometry were predominating factors in determining endurance life for welds of acceptable aircraft quality. Results confirm previous data on superiority of tapered and concave fillets and deleterious effect of internal weld defects.

Solid Body Mechanics in Relation to Mechanical Engineering. Sir Charles Inglis. *Institution of Mechanical Engineers, Proceedings*, Vol. 157, *War Emergency Issue No. 31*, 1947, pp. 271–274.

How to Organize for Experimental Stress Analysis. *Product Engineering*, Vol. 19, No. 4, April, 1948, pp. 113–136, illus., diagrs.

A survey of commercial strain gage equipment. The principles, approximate cost, applications, and limitations of the brittle coating, photoelastic, electric strain gage, and extensometer systems are given. A few selected references for each system and for experimental stress analysis in general are included.

The Optical System of Polariscopes as Used in Photoelasticity. C. Mylonas. *Journal of Scientific Instruments*, Vol. 25, No. 3, March, 1948, pp. 77–81, illus.

The designing of a new polariscope at University College, London. Uniformity of illumination of the optical field and the sharpness of the isochromatics depend on the size of the light source, on the sizes, focal lengths, and respective positions of the condenser, collector, and camera lens, and on the thickness of the specimen. The size and thickness of the specimen to be used determine the optimum for the characteristics of the other elements in the optical system.

Electronic Stroboscopes; Short-Duration-Flash Equipment; Basic Operating Principles. Alan E. Crawford. *Aircraft Production*, Vol. 10, No. 113, March, 1948, pp. 101, 102, illus., diagrs.

Photoelastic Investigation of Stress-Relieving Fillet Curves. Everett Chapman. *Product Engineering*, Vol. 19, No. 5, May, 1948, pp. 138–141, illus.

Description of a photoelastic polariscope in which accurate optical alignment is maintained by mounting the condenser housing, the straining frame, the field lens housing, and the photographic viewing station on two alignment bars. The application of load to the specimen and scanning of the loading area can be controlled from the viewing station. The necessary equipment and the procedure in making test models from CR-39 cast resin are enumerated. An investigation of the stress concentrations occasioned by the contour of the keyways in the hub of a compressor illustrates the application of photoelastic stress analysis in the design of machine parts.

The Optical System in Photoelastic Observations. H. T. Jessop. *Journal of Scientific Instruments*, Vol. 25, No. 4, April, 1948, pp. 124–126, figs.

The projected fringe pattern can be made to represent most accurately the stress distribution in a parallel plate model by employing a comparatively large source of light and cutting down the light actually used in projecting the image by placing a diaphragm in the projecting lens and by using a collimating lense to collect the "parallel" rays from the model. The aperture of the projecting lens diaphragm should be placed at the principal focus of this collimating lens.

Simultaneous Measurement of Tensional and Electrical Resistance of Fine Wires. J. T. Norton and G. C. Kuczynski. *Instruments*, Vol. 21, No. 4, April, 1948, p. 328, figs. 2 references.

Description of an analytical balance modified to permit the elongation of the wire under load to be measured with a cathetometer and its gage factor to be measured with a d.c. Wheatstone bridge.

A Fifty-Point Bridge Balance Unit for Use With a Baldwin SR-4 Strain Indicator. N. C. Fick and N. A. Crites. *Instruments*, Vol. 21, No. 4, April, 1948, pp. 329, 330, illus.

In order to read fifty strain gages consecutively during the progressive loading of a structure, 5-gang 11-point switches were used to permit selection of the desired gage. Each gage was balanced by a compensating gage mounted on a ring that could be deformed by the operator as required.

Simplified Dynamic Strain Equipment. Will J. Worley. *Instruments*, Vol. 21, No. 4, April, 1948, pp. 330–332, figs. 3 references.

A method by which the Baldwin-Southwark portable strain indicator may be adapted to repeated dynamic strain measurements. The phase-discriminating rectifier and the indicating instrument in the strain indicator are cut out of the circuit, and for

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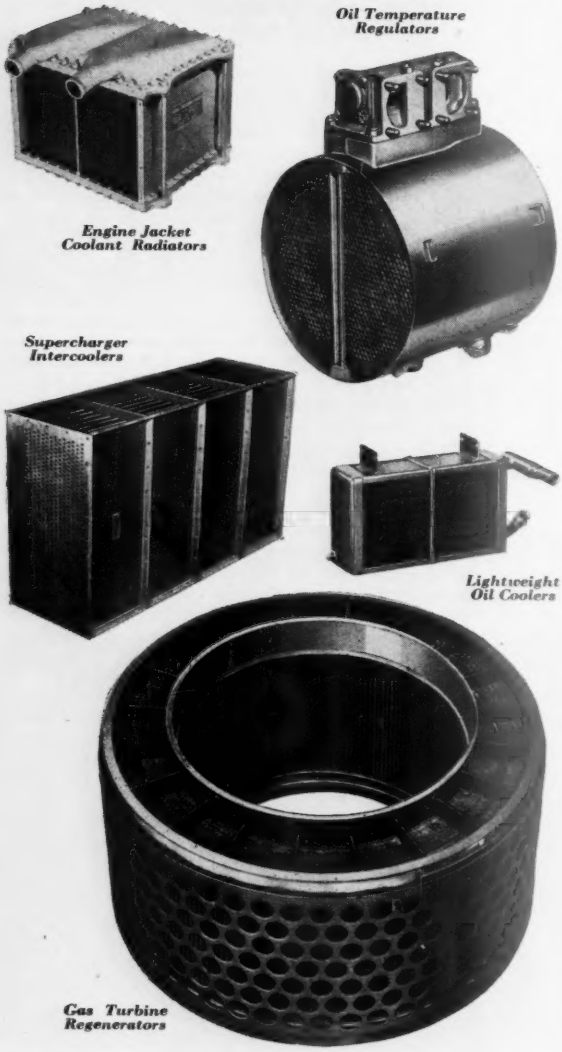

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them an oscilloscope is substituted. The dynamic measurements can then be made from the oscilloscope patterns.

The Acoustic Strain Gauge. *Muirhead Technique*, Vol. 2, No. 1, January, 1948, pp. 4–7, illus. 5 references.

This measuring device employs a stretched steel wire clamped to the structure under test. The frequency of vibration of the wire is a direct measure of the strain occurring in the structure. The wire is excited electromagnetically, and its frequency of vibration is matched against the note emitted by a second steel wire whose tension can be varied by a calibrated control. The test gage frequency may be transmitted to the comparison unit either by an electrical or a radio circuit permitting measurements to be made at remote locations by visual comparison of calibrated dials, oscillograph display, or photographic record.

Thermodynamics (18)

Thermodynamics. I—The Second Law From the Standpoint of the Equation of State. J. L. Finck. *Franklin Institute, Journal*, Vol. 245, No. 4, April, 1948, pp. 301–317, figs. 4 references.

The Kelvin-Planck and the Clausius principle arise from the conventional restriction of the equation of state to a two-variable system. The asymmetric view of nature in which entropy always increases, which they express, is caused by the incomplete equations of state. If all the independent variables involved were used, the system would be completely reversible. De Donder introduced a third variable into the equation of state, defined as the degree of advancement of the chemical reaction taking place within the system. In such a system there is no integrating factor that will make the infinitesimals added to the heat of the system integratable either in the pressure-volume-temperature space defined by the mass ratio of the states, temperature, and pressure. This makes meaningless De Donder's concept of uncompensated heat. Caratheodory's development of the second law uses a Pfaffian lemma, which possesses a factor making it completely differentiable and in which all but one of the variables are configuration coordinates that appear in the expression for the word done by the system. If, however, other variables are needed to define the system completely, the lemma calls for the existence of irreversible processes for a completely defined system, which is impossible. Thus, the entropy function exists only when incompletely defined systems are employed and when quantities such as the degree of transformation are not used as integrating factors for the heat additions to the system.

Water-Borne Aircraft (21)

Effect of Partial Wing Lift in Seaplane Landing Impact. Stanley U. Benscoter. *U.S., N.A.C.A., Technical Note No. 1563*, April, 1948. 14 pp., figs. 3 references.

A solution of the motion of a prismatic float of infinite length with constant partial wing lift to determine the maximum acceleration when it is dropped vertically into the water at zero trim. The float is assumed to have a uniform mass per unit of length and a uniform wing lift per unit length. The mass ratio at the instant of maximum acceleration depends on a single dimensionless parameter that involves the initial conditions and the float properties. While the partial wing lift may have a small effect on the maximum acceleration, the effect is small enough to be disregarded in most practical design cases.

Hydrodynamic Research in Germany. U.S. Naval Technical Mission in Europe. *Gt. Brit., British Intelligence Objectives Sub-Committee, Miscellaneous Report No. 59*, September, 1945, 18 pp. 13 references. British Information Services, New York. $0.70.

Notes on the points of view and procedures in hydrodynamic research, flying-boat development, and investigation of the stability of torpedos or other free bodies running on course or diving. The quality and efficiency of German research is compared with that of American and British research.

Planing of Watercraft. Herbert Wagner. (*Jahrbuch der Schiffbautechnik*, Vol. 34, 1933, pp. 205–227.) *U.S., N.A.C.A., Technical Memorandum No. 1139*, April, 1948. 41 pp., diagrs. 7 references.

A theoretical investigation of the processes accompanying the planing of a planing surface at constant attitude and velocity on an originally smooth surface. The simple limiting cases that are treated supply a picture of the planing processes which enables the interpretation of experimental results.

Dangers Taken Out of Ditching by Special Flap and Foil Devices. Robert McLarren. *Aviation Week*, Vol. 48, No. 15, April 12, 1948, pp. 19, 20, diagrs. 9 references.

The hydroflap, a long inclined plate installed beneath the nose of an airplane or under the forward portion of the engine nacelles, absorbs the water impact when ditching. It allows the craft to plane along with nose and forward portion of the fuselage out of water while momentum is being dissipated. The hydrofoil, a dihedral planing surface suspended below the nose of the aircraft, accomplishes the same purpose, but in addition it generates considerable lift when it becomes immersed and tends to rise to the surface of the water.

Hydrodynamic Qualities of a Hypothetical Flying Boat With a Low-Drag Hull Having a Length-Beam Ratio of 15. Arthur W. Carter and Marvin I. Haar. *U.S., N.A.C.A., Technical Note No. 1570*, April, 1948. 39 pp., illus., diagrs. 4 references.

The hydrodynamic qualities of importance in practical operation determined in this investigation were the range of position of the center of gravity for take-off, landing stability, spray characteristics, and take-off performance. The results indicate that the hydrodynamic qualities of this low-drag hull are satisfactory and do not differ greatly from those of the related flying boat with the more conventional hull length-beam ratio of 6.

Ditching Tests With a $^1/_{10}$-Size Model of the Army A-20A Airplane. I—Calm-Water Tests in NACA Tank No. 2. John R. Dawson and George A. Jarvis. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-584)*, November, 1943. 20 pp., illus. 1 reference.

Tank Tests of a $^1/_8$-Size Dynamic Model of the PB2Y-3 Airplane With Simulated Jet Motors—NACA Models 131J, 131J-1, and 131J-2. Joe W. Bell and Robert F. Havens. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-687)*, June, 1943. 28 pp., illus., figs. 3 references.

Wind Tunnels (17)

The Design and Work of the Farnborough High Speed Tunnel. A. Thom and W. G. A. Perring. *Royal Aeronautical Society, Journal*, Vol. 52, No. 448, April, 1948, pp. 205–247, Discussion, pp. 247–250, illus., diagrs.

The design and construction of this R.A.F. wind tunnel and a summary of the work accomplished. Initial planning of the tunnel was begun in 1937 to provide facilities for the study of the effects of compressibility on the performance of aircraft. The actual construction of the tunnel was simultaneous with the testing of models of the tunnel. Modifications were incorporated during construction—e.g., the mixing vanes that reduced the periodic pulsations in the tunnel model were used to the same effect in the full-scale tunnel. Structural details, the cooling system, and the design of the tunnel's fan are treated, as well as the method of supporting the model and the mechanism of the balance. A detailed description is given of the calibration of the tunnel and the problems it presented in instrumentation and correction of scale effect. Since its completion in 1942 the tunnel has been in continuous operation; recently it has been used to investigate the effect of sweepback and compressibility on longitudinal stability and control and on the characteristics of airfoils.

Stability Derivatives: Wind Tunnel Interference on the Lateral Derivatives l_p, l_r and l_v With Particular Reference to l_p. J. M. Evans. *Australia, Council for Aeronautics, Report No. ACA-33*, March, 1947. 18 pp., figs. 5 references.

The wind-tunnel correction for the rolling moment of a wing was computed for a tunnel of circular cross section by the method of images. The circulation was split up into a symmetric distribution whose magnitude depended on the lift of the wing and an antisymmetric distribution due to the rate of roll in free air plus that caused by the image system. By conformal mapping of the interior region of a rectangle on to the interior of a circle, these results were used to calculate the interference on a wing in a tunnel of rectangular cross section. Results are given for tapered wings with an aspect ratio of 6 in a 9 by 7-ft. rectangular tunnel at 0° and 90° angle of bank. The damping derivative in roll due to rolling apparently is increased by tunnel interference in closed tunnels and reduced in open tunnels.

Visualisation of Boundary Layer Flow. J. H. Preston. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2267*, November, 1946. 6 pp. 23 references. British Information Services, New York. $0.45.

Brief description of methods of determining transition from laminar to turbulent flow by the use of filaments of smoke or chemically active gas, by contamination, evaporation, and similar techniques. A résumé of important contributions to this subject prior to 1940 and a comprehensive bibliography are included.

Summary Reports Concerning Wind-Tunnel Corrections in Compressible Flows. Carl Wieselsberger. *U.S., Air Force, Translation No. F-TS-2085-RE*, March, 1948. 12 pp., figs.

A summary of the corrections required for wind-tunnel effects at high supersonic speeds. The correction for the stream velocity and the loss in drag in both circular and rectangular test sections is obtained for incompressible flow and, by the application of Prandtl's rule, is derived for compressible flow. In cases where Prandtl's rule does not apply, an additional measurement of the turbulent velocity at the tunnel wall will enable a calculation for compressible conditions. The corrections for lift, induced drag, and angle of attack for compressible flow in closed and free-stream tunnels are obtained by a similar treatment.

An Improved Schlieren Apparatus. Frank W. Barry and Gilbert M. Edelman. *Journal of the Aeronautical Sciences*, Vol. 15, No. 6, June, 1948, pp. 364, 365, illus., diagrs.

This improved schlieren apparatus forms two separate images of the test section simultaneously. One image indicates vertieal density gradients, the other horizontal density gradients. The light from the original source is split into two beams. One retains its original orientation and direction. The other retains its original direction but is rotated through 90°. Each beam passes one of two mutually perpendicular knife edges and passes from these through the test section. After leaving the test section the two beams are separated by optical means and allowed to impinge on a photographic film. The determination of transient density fields is more accurate with this modified schlieren system than with the ordinary system, which requires the taking of two successive pictures.

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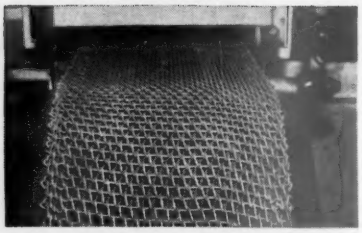

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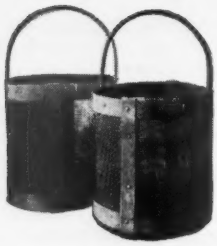

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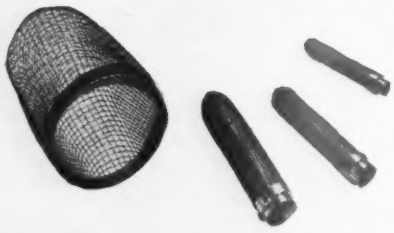

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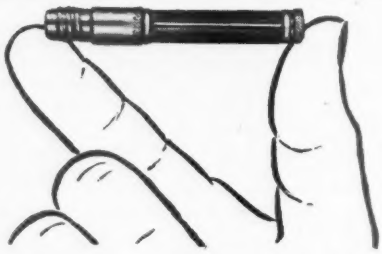

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Books

Ballistics of the Future

By J. M. J. Kooy and J. W. H. Uytenbogaart. New York, McGraw-Hill Book Company, Inc., 1948. 472 pp., illus., diagrs. $12.

It is not often that the story of a technical book deserves to be told, but the way in which *Ballistics of the Future* came into being does deserve the telling. During the second World War Dr. Kooy, of the Aeronautical School, The Hague, decided to write a mathematical treatise on the "dynamics of the projectile and the rocket under the influence of the field of gravity of the earth and of the atmosphere, as well as beyond, in world space"—an excellent subtitle. Because of his great experience in, and personal partiality for, problems in this sphere, Dr. Kooy finished his task toward the end of World War II in spite of the delays and difficulties brought about by the German occupancy of Holland. "Crazy Tuesday" (September 5, 1944) was a sort of Appendix, horrifying yet pertinent. The Germans tried out their V-weapons before their technical development was complete and inflicted an indescribable inferno on The Hague and its beautiful garden suburb of Wassenaar. "The prompt and vigorous counter-measures of our Allies made life still more unbearable." Dr. Kooy lost none of his interest in the subject of rockets as weapons because of these horrors. Once the war was over, he approached Dr. Uytenbogaart, Professor of Mechanical Technology at the Technical University of Delft, who had made a special study of the V-weapons for the benefit of the United Nations. To the theory Professor Uytenbogaart added a wealth of technical detail. The publishers crowned his happy and appropriate collaboration by wisely issuing this fine book, for the benefit of American and British readers, in English, though somewhat indifferent English. Fortunately, the splendid mathematical presentation more than compensates for the diction.

What is the best introduction to a study of the complexities of modern ballistics? A sound, working knowledge of vector calculus, advanced dynamics, and the numerical integration of the unpleasant differential equations with which the subject bristles. At some time or other the engineer, or physicist, particularly the one who has had a year or two of graduate study, has delved into all three of these topics. But he has studied them at different times and from different points of view. In *Ballistics of the Future*, a skillful teacher presents them concisely and is mindful of a purpose. The 27 pages of Chapter I, Vector Calculus, recall to the reader, clearly and in a good notation, all the vector analysis he needs to know and must know to study Chapter II, Vector Calculus Applied to General Dynamics. Chapter III, Dynamics of the Solid, covers well such topics, indispensable in advanced ballistics, as Stable and Unstable Axes of Rotation, Euler's Equations, General Equations of Motion of the Solid, etc. In many branches of aeronautics, the modern research engineer cannot shirk the Theory of Generalized Coordinates and Lagrange's Equations. He will be pleased with Chapter IV, On the Equations of a Connected System. Those who studied differential equations in the first decade of the twentieth century learned many dodges for their solution. When such "dodges" were not available, in a particular equation, the students were merely told that the equation was unsolvable. The word unsolvable does not exist in the modern teaching of mathematics. Even if no calculating machine is available, everything can be solved, and Dr. Kooy has collected and set forth very practically in Chapter V, Numerical Integration, the powerful methods of Newton-Cotes, Gauss, Tschebyscheff, Runge, and Kutta.

Thus the first five chapters, roughly one-fourth of the book, if carefully studied, provide all the analytical tools and constitute an imaginary Part 1. If one wished to continue this division, then Part 2 would comprise the following group: Chapter VI, The Projectile as Material Point; Chapter VII, General Theory of a Gravitating Spinning Top; Chapter VIII, The Projectile as a Solid, and Chapter IX, Terrestrial Dynamics of the Rocket.

It was puzzling to read the title of Chapter VI, The Projectile as Material Point. The authors kindly explain this at the beginning of the chapter. They say that in most practical cases—that of a bullet or shell or an airplane bomb—the simplifying assumption can be made that, with the aid of vanes or fins, the longitudinal axis will always be along the direction of motion. With this ideal tractability the only aerodynamic force acting is the air resistance, and we can consider "the projectile as a material point, coinciding with the center of gravity, at which the total mass is concentrated and all external forces apply." Even with this simplification the chapter offers difficult reading, with the following subheadings as proof: integration by steps of the orbit of a projectile, by the method of Runge and Kutta; motion of projectile on rotating earth, taking into account the air resistance, the variation of the gravitational, and the centrifugal field with the altitude and earth's rotation; etc. Since, unfortunately, the projectile does *not* have ideal "tractability," it is logical to study in Chapter VII, The General Theory of a Gravitating Spinning Top, and in Chapter VIII, The Projectile as a Solid, to consider the Magnus effect, the gyroscopic effect, the equations of motion of the rotations about the center of gravity, etc.

In Chapter IX, Terrestrial Dynamics of the Rocket, the authors pass into a more practical phase. They define the rocket and speak of jet propulsion. They study the motion of a rocket in simple idealized cases first, in accelerated flight and in perpendicular ascent, and pass on to such a nice problem as "motion of the rocket, accounting for the air resistance, wind, earth's rotation, curvature of the earth's surface and variation of g with the altitude." The mathematical equations become long and formidable. To compensate, we have some fascinating reading on escape from the earth, how to turn in space, etc. There is also a rewarding discussion of the use of an automatic pilot in the rocket which has scarcely appeared before in unclassified literature.

It is no doubt with Chapter X that Professor Uytenbogaart becomes the more active partner. The robot plane V I (Vergeltung Eins) was "a small airplane flying without a crew,

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driven by a primitive kind of reaction motor and steered by an automatic pilot." There is much to learn from its thorough and technical description. To anyone interested in the design of guided missiles, the long-range artillery of the future, Chapter XI, The German Giant Rocket V 2 (Vergeltung Zwei), is, most certainly, "required reading." Thermodynamics of the rocket motor accompany its detailed description; combustion *plus* dissociation are well treated; so are fuels; so are mechanical controls and steering with its combination of gyroscopic and electrical principles; so are the calculations of launching and trajectory. Chapter XII, Extra-Terrestrial Dynamics of the Rocket, is a fine dessert for a substantial meal. Here is no mere imaginative writer idly speculating about a flight to the moon. Here are two technicians dealing soundly and mathematically with questions that we can best define by direct quotation:

"In this chapter we shall briefly describe how the rocket flight in world space can be treated in mathematical terms, when the problem of the propulsion has been sufficiently solved. In general in these considerations we shall assume that the rocket carries human occupants, or in any case that it is possible, by suitable steering manipulations, to adjust the direction of the gas reaction force. Further we shall assume that the rocket is sufficiently remote from the earth, so that it moves in an absolute vacuum. As long as the rocket is in the immediate neighbourhood of the earth, we may consider it as only acted upon by the attraction of the earth and the gas reaction force. But when the rocket is at greater distance from the earth, the disturbing influence of the moon, and also of the sun, must be taken into account."

Writing this review on a hot day, we do not recommend this book for light summer reading. For those professionally interested, we recommend it as scholarly, sound, and thoroughly worth while to a vast subject that is, unfortunately, of high national importance.

Dr. Alexander Klemin
Consulting Engineer
Greenwich, Conn.

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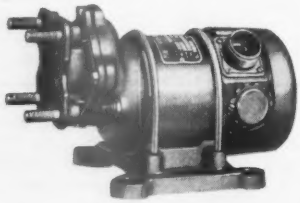

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World Aviation Annual, 1948

Washington, D.C., Aviation Research Institute and the James Jackson Cabot Professorship of Air Transportation of Norwich University, 1948. 540 pp., illus., maps. $17.50.

The need has long been felt for an authoritative annual reference work giving world coverage on air transport operations, companies engaged in air transport and aviation manufacturing, registered aircraft, exports and imports of aeronautical products, and other factual information. This book fills this need admirably, giving data in both English and metric units on the status of aviation in 94 countries, grouped into eight trade regions.

The economic characteristics of these regions are given in the 18-page world summary, which opens the book. This includes tables showing the total world scheduled route miles in 1947 to be 957,093 miles, as compared with 451,360 miles in 1938; plane miles flown in 1947 to be 824,902,000 miles as against 675,796,000 miles in 1946 and 229,530,000 in 1938; and civil aircraft registrations in 1948 to be 111,442 against 22,499 in 1938. There were 247 scheduled air carriers active in January, 1948, operating 4,378 planes, and there were 2,453 nonscheduled operators, of which about 195 were operating in Greater Europe, 68 in Middle and South America, 47 in Africa, 25 in Asia, and 18 in Australia and New Zealand.

Statistics are presented in detail in the main part of the book by trade regions and by countries. A typical outline of information on a country includes data on the scope and functions of the principal government and private agencies; military and naval aviation; a chronology of principal historical events and legislative acts; dates and provisions of international agreements in effect; the air-frame, engine, and accessory manufacturing companies, including production and

financial data; exports and imports of aeronautical products; surveys of scheduled air carriers, including historical and financial data, management, routes, personnel, equipment, and operating statistics; similar surveys of the principal nonscheduled operators; airports of entry, air navigation facilities; registered aircraft, aero clubs, status of personal flying; aeronautical publications; and practical information for the air traveler on exchange rates, entry requirements, hotels, routes, and fares.

Data are given on more than 200 manufacturing companies, including brief descriptions of their principal products. Over 70 of these are in the United States, and 98 are in Greater Europe, including 44 in the United Kingdom, 21 in France, and 10 in Italy. Russia has about 20 air-frame factories, and about 40 component factories. Most of these are located in the region east and south of Moscow, in European Russia, although isolated factories exist in the Urals and points east. Russian production, which rose to 40,000 planes during the war, mostly fighters, light bombers, and attack planes, is still at full capacity, but more large transports and heavy bombers are being produced. The estimated production in 1948 will include about 1,000 B-29 type bombers, and it is believed that about 200 jet fighters per month are being produced. Four factories are in production in Brazil and four in Argentina, three of which are in close cooperation with Italian companies. Production figures are fully available in relatively few countries. Of the countries in production, statistics are given for the U.S. for 1940–1947; Canada, 1935–1946; France, 1946–1947 (first 6 months), and monthly averages for 1938, and 1944–1947; and partial figures for Great Britain, 1946–1947. Air transport operation data are more completely available and in all cases are given for 1947, 1946, and 1938, except where normal service has been disrupted, as in the case of Egypt. Traffic figures are given for earlier years in such active countries as the U.S., Great Britain, Russia, Alaska, Belgium, and France.

However, this is not entirely a statistical volume. The World Prospective includes information on international postal traffic, international regulatory bodies, and multilateral agreements and conventions. Considerable information is included about airplanes, including lists of U.S. and British aircraft, and their popular names, equipment used by operating air lines, and the products of manufacturing companies. The closing sections include an economic notebook, containing a condensed C.A.B. accounting system; a summary of U.S. air carrier characteristics grouped into trunk, territorial, feeder, and international carriers; and a useful reference data section giving English and metric system equivalents, Air Force and Navy airplane designations, and records.

Dr. J. Parker Van Zandt, editor-in-chief, brought to the task of gathering data and organizing this volume more than 30 years of achievement as a military and civil pilot, as a pioneer in blind flying and aviation radio, as a sales and operations executive, and as an analyst, research director, and writer in the field of air transport. He has organized a staff of proved competence. Its production of this volume is a remarkable achievement. This book is indispensable not only to the policymaker and economist but to any organization or person engaged in the study and practice of aviation.

MAURICE H. SMITH
Curator-Librarian, I.A.S.

Aircraft Instrument Maintenance

By Earl F. Werner. New York, McGraw-Hill Book Company, Inc., 1948. 451 pp., illus., tables. $7.50.

Aircraft Instrument Maintenance is a well-balanced blend of practical and theoretical information for the guidance of field service men. The author has restricted his subject matter to standard types of instruments and has treated these clearly and comprehensively from the maintenance standpoint. Chapters One and Two cover many practical details common to the installation, lighting, marking, and in-

AIRviews

Replacement spares for the DC-3, DC-4 and DC-6 commercial models and C-47 and C-54 military models, valued at more than $2,000,000 a month, are currently being shipped to some 350 customers operating in excess of 3,000 Douglas airplanes in all parts of the world.

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PRESIDENT
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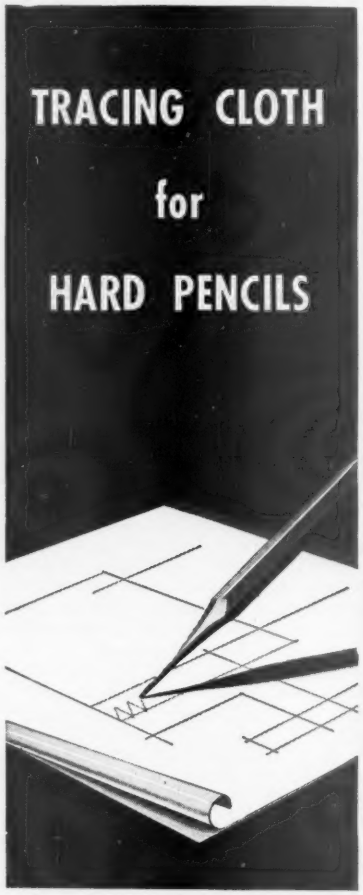
spection of these standard types and include explanations of color-code banding of nonstructural tubing and nomenclature of AN multiple electrical-connector assemblies. The author points out that practically all instruments are applications of five basic mechanisms—the Bourdon, diaphragm, aneroid, gyroscopic and electric—to the instrumentation problems encountered in aircraft operation. The chapters that follow the discussion of the five basic mechanisms are devoted to specific types of pressure gages, tachometers, thermometers, remote indicators, compasses, and gyroscopic instruments. Each instrument is presented according to a definite pattern, the purpose, description, and operation being followed in each case by the more practical topics of installation, maintenance, and interpretation (trouble-shooting). These sections on trouble-shooting should be of considerable value to candidates for C.A.A. mechanic's certificates as well as to line service men who are somewhat weak in this subject. Another valuable feature of the book is the presence of footnotes citing Civil Air Regulations applicable to the accompanying subject matter. Shop overhaul procedures are purposely excluded from the book, since few installations have the technical equipment required to accomplish such exacting work and since instrument repair is outside the scope of line maintenance. The book does not include any discussion of the fuel-flow meter, fuel-air ratio indicator, ice- or stall-warning indicator, terrain clearance indicator, attitude gyro, or such relatively uncommon instruments as Mach meters or accelerometers.

CHARLES C. GREENE
Aeronautics Teacher
Board of Education
City of New York

Aeronautical Conference

London. 3rd–5th September, 1947. Convened by the Royal Aeronautical Society and the Institute of the Aeronautical Sciences. London, Royal Aeronautical Society, 1948. 704 pp., diagrs.

Partial contents: Theoretical Considerations on Stability and Control at High Speeds, Theodore von Kármán. Control in Low Speed Flight, M. B. Morgan. Modern Operational Factors Affecting Airworthiness, K. T. Spencer and P. A. Hufton. Icing Problems, Abe Silverstein. High Speed Testing in the Southern California Co-Operative Wind Tunnel, C. B. Millikan. High Speed Performance, W. G. A. Perring. The Economics of Personal Aircraft, Grover Loening. Electronic Control and Instrumentation of Aircraft, Martin Kiebert. Structural Problems of Large Aircraft, Henry Knowler. Thin-Walled Monocoques, N. J. Hoff. Résumé and Analysis of N.A.-



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Book Notes

AIRPORTS & AIRWAYS

Airport Lease and Concession Agreements. Charles S. Rhyne. Washington 6, D.C., National Institute of Municipal Law Officers, 1948. 206 pp. $7.50.

The author's purpose is to analyze the problem of agreements governing airport use between cities, air lines, fixed-base operators, and concessionnaires. Court decisions and airport leases under the Civil Aeronautics Act of 1938 and the Federal Airport Act of 1946 are reviewed in the first chapters. Airport revenues, financing, and costs of operation are discussed in Chapter 5, and these 70 pages are among the most valuable in the book, covering the current practices of typical airports in detail. The final half of the book deals with model agreements and notes on their use. Five articles and documents on revenues, rates, and airport operation are included in an appendix.

ELECTRONICS

Microwave Transmission Design Data. Theodore Moreno. New York, McGraw-Hill Book Company, Inc., 1948. 248 pp., diagrs. $4.00.

The purpose of this book is to provide a reference handbook on microwave transmisson lines and associated components for the radio engineer working in the ultra-high-frequency field. The first three theoretical chapters deal with general considerations, attenuation, impedance matching, reflections and standing waves, and impedance relations on microwave transmisson lines. "General Formulas for Coaxial Lines," "Flexible Cables," and "Coaxial Line Structures and Transformers" are taken up next. About a third of the book is concerned with the next topic of wave guides, with particular emphasis on practical structures and components. A summary of M.I.T. reports on dielectric materials is given in the next chapter and the final chapter deals with cavity resonators. The book is a greatly expanded and revised version of a publication of loose-leaf notes issued in 1944 by the Sperry Gyroscope Company.

MATERIALS

Literature Survey on the Low-Temperature Properties of Metals. A. E. White and C. A. Siebert. Ann Arbor, Mich., Edward Bros., 1947. 558 pp., tables. $7.50.

This is more than a literature survey because the data on the physical properties of alloys at subzero temperatures are reproduced in 492 tables from 50 references. Nonferrous alloys are dealt with in 81 tables, including 19 on aluminum and 7 on magnesium. Copper, copper-zinc alloys, bronzes, nickel and copper-nickel alloys, and lead and tin alloys are included. The remaining 411 tables deal with steels having one, two, or three alloying elements, arranged according to type of alloy, and with plain steels and irons. Tensile strength, hardness, and yield point increase in ferrous materials at low temperatures, and there is a decrease in value of the reduction of area, elongation, and impact resistance. The transition from a tough fracture to a brittle type usually occurs in a rather narrow temperature interval. Nonferrous materials maintain their room-temperature physical properties or show an improvement at low temperatures. The report was originally issued in 1942 by the Office of Scientific Research and Development.

NAVIGATION

Navigating Your Airplane. Creighton Merrell 3rd Ed. Seattle 8, Wash., Merrell Aviation Ground School, 1947. 95 pp., illus., diagrs.

The practical treatment in this book is its outstanding characteristic. The accompanying illustrations are well executed and are particularly valuable in a book on this subject. Emphasis is placed on the step-by-step procedure in navigating a cross-country trip, the characteristics of the various types of map projections, course plotting (both rhumb and great circle courses), navigation instruments, and wind vector problems. Shorter chapters are included on methods of navigation, divisions of the earth, time and longitude, and chart reading. Problems and answers are included, as well as a sample examination.

PRODUCTION

Design of Metal Cutting Tools. Frederic L. Woodcock. New York, McGraw-Hill Book Company, Inc., 1948. 406 pp., illus., diagrs. $5.00.

The author's purpose is to present the basic principles of design for the construction of tools to be used in mass-production manufacturing. The book developed from rules, formulas, and tabulated data assembled for the guidance of designing engineers in a plant manufacturing commercial cutting tools and later in an organization manufacturing precision aeronautical apparatus. It represents experiences and actual practices in high-precision production work and should be useful to the tool designer, draftsman, checker, production engineer, shop superintendent, and the student and teacher. The first 64 pages deal with the fundamentals of design: Economics and Standardization, Elements of Cutting, Maintenance, Inspection and Sharpening, Cutting-Room Materials, Heat Treatments, and Cutting Fluids. The greater part of the book deals with details of design of broaches, counterbores and countersinks, cutters, drills, form tools, hobs, punches and dies, reamers, shaper tools, single points, threaded tools, and other cutting tools. Standard data on taper shanks, die blanks, threads, and wire methods of measurement are given in a 61-page appendix. The author is Chief Tool Engineer of the Hamilton Standard Propellers Division of the United Aircraft Corporation.

Quality Control in Industry; Methods and Systems. John G. Rutherford. New York, Pitman Publishing Corporation, 1948. 201 pp., illus., figs., tables. $3.50.

A textbook on the general principles of quality control and the statistical methods used in the practical application of these principles to industrial problems. The book is intended for students who need an introduction to quality control organization and practice in industry and for those in industrial quality control departments who need a simple and comprehensive guide to theoretical data and methods. The book is divided into two parts. Part I covers the general principles and contains eight chapters on the topics of Functions and Responsibilities, Organization, Economics of Quality Control, Control of Quality-Department Costs, Reports and Records, Personnel Training, Relations to Other Departments, and Customer Representatives. Part II, on Statistical Methods, comprises about two-thirds of the volume and provides detailed explanations of The Principles of Statistical Methods, Sampling Inspection, Process Control, Specialized Applications (Treatment of Raw Data, The Frequency Distribution—Large Samples, and Average and Standard Deviation—Large and Small Samples), Further Specialized Applications (Sample Averages and Standard Deviations—Large and Small Samples and Design of Tests), and the Practical Application of Statistical Methods. The Appendix, of 13 pages, contains 12 tables of mathematical data, a glossary of commonly used symbols, a summary of 19 equations introduced in the text, and a list of ten American and British books on statistics. The text is well illustrated with facsimiles of sampling and inspection forms, organizational charts, graphs, and curves. It contains, in addition to those in the Appendix, 22 tables. Summaries are given at the end of chapters, and there is an adequate subject index.

SCIENCES, GENERAL

MATHEMATICS

Modern Operational Calculus, With Applications in Technical Mathematics. N. W. McLachlan. London, Macmillan and Company, 1948. 218 pp., diagrs. 21*s*.

The author's purpose is to present an introduction to modern operational calculus based on the Laplace transform, for postgraduate engineers and technologists, and advanced undergraduates in mathematics. The Laplace transform method of solving ordinary and partial linear differential equations, being logical and unambiguous, is preferable to that of Heaviside. The treatment in this book is more rigorous than is usual in a work on technical mathematics. Uncertainty of mathematical analysis through lack of reasonable rigor is compared to lack of mechanical accuracy in the solution of engineering problems. Following the establishment of various theorems, their applications are taken up in the solution of ordinary and partial linear differential equations, the evaluation of difficult integrals, in obtaining mathematical relationships and expansions, and in the derivation of Laplace transforms of various functions. A modern treatment is introduced of periodic impulses of finite and infinitesimal duration based upon complex integration. The final quarter of the book contains appendixes for readers who wish to review Heaviside's unit function. They also include various definitions and theorems pertaining to infinite series and infinite integrals. This is an important book for those interested in mathematical solutions of engineering problems, and it should be received by a wide audience.

MECHANICS

Dynamics. S. L. Green. London, University Tutorial Press, Ltd., 1948. 264 pp., diagrs. 10*s*. 6*d*.

This is intended as a textbook in the dynamics of a particle and of a rigid body for the student prepared in the principles of mechanics and having an elementary knowledge of differential equations. Vector methods are introduced in the first chapter. The first half of the book is concerned with motion of a particle in a straight line and in a plane, as well as projectiles; circular and cycloidal motion; use of polar coordinates, central orbits, and center of mass; coefficients of inertia; and motion of a system of particles. The second half deals with motion of a flat plate in its plane, of a rigid body about a fixed axis, of a rigid body in two dimensions, and impulsive motion of a rigid body. Each chapter is accompanied by 15 to 35 or more examples, to which answers are supplied. The author is a lecturer in mathematics at the University of London.

Necrology

Leon Beskin

(*Continued from page 18*)

and was educated at the Central School of Arts and Manufacturers where he received his Engineering Degree in 1932 as the first ranking student of 250.

In addition, he also held a law degree from the University of Paris, as well as a degree in theoretical mechanics from the same University.

In October, 1932, he was employed as a Stress Analyst, working on mechanical superchargers, at the Gnome & Rhône Engine plant in Paris.

Later, in 1934, he went to the works of Société des Avions Louis Breguet in Paris as Stress Analyst and Aerodynamicist, working on preliminary design of aircraft including seaplanes.

Between 1935 and the time of his departure for the United States, Mr. Beskin was employed as a Consulting Engineer for the Baudot Engine Works; the Gnome & Rhône Company; the general contracting firms, Enterprise Rousaud & Fils, Etablissements Cogez, Etablissements Delattre & Frouard; and others, in which he designed and supervised the erection of steel and concrete hangars based on the shell and membrane principle.

In this country, Mr. Beskin worked with structural engineering companies in New York, solving special design problems connected with hangar construction and handling gear for blimps and ships until March, 1943. He patented a new type of hangar door for the Navy Department.

▶ **With Convair**—In 1943 he was appointed Senior Stress Analyst at the Allentown, Pa., plant of Consolidated Vultee Aircraft Corporation. Later he was promoted to Structures Engineer and Design Specialist.

In 1947 he resigned to become Assistant Chief for Design & Research, BuAer, Navy Department, and was promoted to the post he held at the time of his death.

Mr. Beskin was a frequent contributor to the JOURNAL OF THE AERONAUTICAL SCIENCES and various other technical publications. During 1946 he presented two papers at the Sixth International Congress of Applied Mechanics at Paris.

A Member of the Institute of the Aeronautical Sciences, he also was a member of the American Society of Mechanical Engineers and an associate member of the American Society of Civil Engineers.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Giannini, Gabriel Maria, Ph.D., President, G. M. Giannini & Co., Inc.

Hopper, Rea Earl, B.S. in M.E., Chief Engineer, Hughes Aircraft Co.

Teree, Baboo Ram, B.S. in Ae.E., Engineering Mgr., The Weatherhead Co.

Elected to MEMBER Grade

Bamber, Millard John, B.S. in Ae.E., Aero. Engineer & Head, Wind Tunnel Tests Analysis Section, David Taylor Model Basin, U.S. Navy Dept.

Blakeslee, Raymond Douglas, C.E., Structural Group Engineer, The Glenn L. Martin Co.

Bryan, Leslie A., Ph.D., LL.B., Dir., Institute of Aeronautics, & Prof. of Business Organization & Operations, University of Illinois.

Cate, William Romaine, B.S., Instructor of Math. & Stress Analysis, Northrop Aeronautical Institute, Northrop Aircraft, Inc.

Collins, John H., Jr., B.S. in M.E., Chief Engineer, Performance & Materials Div., Flight Propulsion Res. Lab., N.A.C.A.

Creel, Ralph L., B.S., Civilian Head, Contract Structural Design Section, Bureau of Aeronautics, U.S. Navy Dept.

Cunningham, William, B.S. in Ae.E., Stress Analyst, Continental Aviation & Engineering Corp.

Domina, Frederick Charles, Jr., B.S. in M.E., Design Specialist (Power Plant), The Glenn L. Martin Co.

Dunnington, Francis Alden, B.M.E., Development Engineer, Cornell Aero. Lab.

Fischer, Charles Fink, Ae.E., Comdr., Engineering Officer, A. & R. Dept., N.A.S. (Jacksonville, Fla.).

Gordon, Robert, B.M.E., Res. Project Engineer, Aerojet Engineering Corp.

Herrmann, Charles Robert, B.Ae.E., Aero. Engineer, Republic Aviation Corp.

Keating, Tristan J., B.S. in M.E., Mech Engineer & Asst. Branch Chief of Installations, Power Plant Lab., A.M.C., Wright-Patterson A.F. Base.

Keusch, Richard B., B.M.E., Aircraft Power Plant Engineer, Installation Branch, A.M.C., Wright-Patterson A.F. Base.

Krishnan, Subramania, M. of Ae.E., Graduate Student, Engineering College, Govt. of India Scholarship, New York University.

Luecht, John William, B.S. in Ae.E., Asst. Prof.—Research Engineering and part-time Instructor, Dept. of Aero. Engineering, Engineering Research Institute, University of Michigan.

Lukasiewicz, Julius, B.Sc., Dipl. Ing., Sr. Scientific Officer, Royal Aircraft Establishment (England).

MacMillan, Logan Tompkins, B.S. in M.E., Test Pilot, McDonnell Aircraft Corp.

Olson, Gordon A., B.S., Associate Research Aero. Engineer, Cornell Aero. Lab.

Pfenninger, Werner, Ph.D., Chief of Aerodynamics, Assoc. of Swiss Private Aircraft Industry (Switzerland).

Roth, Morris Edmond, B.S. in M.E., Project Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Sandretto, Peter C., E.E., Asst. Technical Dir., Federal Telecommunication Lab., Dir. of Aviation, International Telecommunication Lab.

Schuld, Emil Peter, B.S. in Ae.E., Lt. Cmdr., Asst. Dir. T.P.T., Chief Flight Instructor, N.A.T.C., U.S. Navy.

Setz, Walter Hans, B.S., Assoc. Res. Aerodynamicist, Cornell Aero. Lab.

Taylor, Thomas Lincoln, C.E., Dir. of Customer Relations Div., The Glenn L. Martin Co.

Webb, Gregory Frank, A.F.R.Ae.S., Higher National Cert. in Ae.E., Project Design Draftsman, The Fairey Aviation Co. Ltd. (England).

Wilder, James Johnston, M.E., Field Engineer, Aircooled Motors, Inc.

Zitza, Curt L., M.E., Design Engineer, The Glenn L. Martin Co.

Transferred to MEMBER Grade

Driscoll, Bernard Joseph, B.S. in Ae.E., B.S. in Bus. & Eng. Adm., Asst. Prof. of Air Transportation, College of Aeronautics, University of Southern California.

Gray, William Edwin, Jr., M.E., Flight Engineering Inspector, C.A.A.

Holdahl, Robert Austin, M.S., Assoc. Scientist & Head of Facilities, Aero. Lab., University of Minnesota.

Lindstrom, Rodger Gordon, B.S. in Ae.E., Project Structural Engineer, McDonnell Aircraft Corp.

Paulovich, Kenneth, B.Ae.E., Instructor, Mechanical Engineering Dept., University of California.

Rasmussen, Borge Anders, B.S. in Ae.E., Interiors Designer, Douglas Aircraft Co., Inc.

Rush, Charles Kenneth, B.Sc. in M.E., Aerodynamicist in Charge of Wind Tunnel Operations, National Res. Council (Canada).

Savage, William Frederick, B.Ae.E., Instructor of Aero. Engineering, University of Kentucky.

Schwartzapfel, Wilbert, B.Ae.E., Assoc. Engineer, Cornell Aero. Lab.

Simmons, Stanley Herbert, B.S. in M.E., Mech. Design & Structural Engineer, Los Alamos Scientific Labs., University of California.

Zimney, Charles Marshall, M.S. in Ae.E., Asst. Prof. of Aero. Engineering, University of Minnesota.

Elected to Associate Member Grade

Burbank, Kershaw, B.A., Partner, Burbank Associates.

Stoner, Marvin Le Roy, Staff Engineer, Society of Automotive Engineers.

Transferred to Associate Member Grade

Louis, Harry, M.E., Supt. of Engineering, Canadian Pacific Air Lines Ltd. (Canada).

Elected to Technical Member Grade

Carpenter, Fay Dalton, B.A., Vibrations Engineer, The Glenn L. Martin Co.

Crumpecker, Edward Lawson, B.S., Flight Test Engineer, The Glenn L. Martin Co.

De-Lorenzo, George John, Aviation Machinist Mate, Second Class, U.S. Coast Guard AR/SB.

Kennedy, Herbert Samuel, B.S. in Ae.E., Ensign—Student Pilot, U.S. Navy.

McHeffey, Murray Parker, Engineering Officer, British Overseas Airways Corp.

Morley, Leslie Sydney Dennis, Engineering Student, College of Aeronautics (England).

Perkins, Frank Melvin, M.E., Aerodynamicist, Consolidated Vultee Aircraft Corp.

Zubkoff, Maurice Joseph, B.M.E. Asst. Mech. Research Engineer, Cornell Aero. Lab.

Transferred from Student to Technical Member

Alperin, Jerome, B.S.Ae.

Bitner, Robert Owen, Assoc. in Arts in Ae.E., Sr. Draftsman, The Glenn L. Martin Co.

Blackwell, Roy Nathaniel, Ae.E., Design Section of Engineering Div., McDonnell Aircraft Corp.

Brewer, Paul Edward, Jr., B.S., Draftsman "B," Consolidated Vultee Aircraft Corp.

Burns, Lester William, B.S. in Ae.E., Stress Analyst, Goodyear Aircraft Corp.

Caldwell, Allan Linwood, B.Sc., Engineering Asst. (Graduate Trainee), Consolidated Vultee Aircraft Corp.

Cook, Billy James, Assoc. in Arts in Ae.E., Engineering Draftsman, The Glenn L. Martin Co.

Dager, William Elwood, Mathematician, Douglas Aircraft Co., Inc.

deLancey, Lawrence Marl, B.S., Aero. Engineer, Ordnance Testing Station, U.S. Navy.

de Neufville, Albert, M.S.

Dunkle, David Forest, Jr., B.S. in Ae.E., Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Fogarty, Laurence Eugene, B.S., Student, Cornell University.

Gebhard, James Walter, B.Ae.E., Detail Engineer, Allison Div., General Motors Corp.

Hample, Joseph M., B.S., Design Engineer, Airplane Div., Curtiss-Wright Corp.

Helton, Eldred Howell, B.M.E. (Ae. Option), Aero. Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Hodess, Joseph Meyer, B.S. in Ae.E., Engineer, Brooks & Perkins.

Howell, Robert, Aero. Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Lane, Robert D., Mathematician B, North American Aviation, Inc.

Louie, William, B.S. in E.E., Instrument Development, Instrument Laboratory, Inc.

Lowrey, Orvey Preston, Jr., B.S. in Ae.E., Production Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Luthman, Paul A., B.Sc., Sr. Detailer, McDonnell Aircraft Corp.

Mabry, George Cecil, Jr., B.Ae.E., Flight Test Analyst, Douglas Aircraft Co., Inc.

MacKay, James Kenneth L., B.A.Sc., Jr. Research Officer, National Res. Council.

McCormick, Ralph Lewis, B.S.E., Stress Analyst, North American Aviation, Inc.

Novotny, Edmund Earl, B.Ae.E., Flight Test Engineer, McDonnell Aircraft Corp.

Penland, Jim Alex, M.E. (Ae. Option), Aero. Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Reiser, William Fredrick, B. Bus. Adm.

Riley, Donald Robert, B.S., Graduate Student, The Pennsylvania State College.

Shepard, Thomas Wharton, Jr., B.S. in M.E. (Ae. Option), Engineering Trainee, Chance Vought Aircraft Div., United Aircraft Corp.

Slomski, Joseph Frank, B.S. in Ae.E., Res. Engineer, Flight Propulsion Res. Lab., N.A.C.A.

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Thomas, Edwin Leon, B.S. in Ae.E., Stress Analyst, McDonnell Aircraft Corp.

West, Max Drexel, B.S. in Ae.E., Aero. Engineer P-1, Langley Mem. Aero. Lab., N.A.C.A.

White, Dempsey Deroy, M.E.

Zanotti, George John, Ae.E., Instructor, University of Illinois.

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Personnel Opportunities

This Section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

WANTED

Jet Engine Specialists, Aerodynamicists, and Thermodynamicists—Needed for research and development work on supersonic ram-jet engine projects. Experienced men needed also for development work on electrical, mechanical, and pneumatic control systems—accessory and fuel. Good openings available at present because of large-scale expansion program. Write to, or apply at, Marquardt Aircraft Company, 4221 S. Lincoln Blvd., Venice, Calif.

Engineers and Scientists—The Navy Department is seeking engineers and scientists in practically every field for employment in Washington, D.C. Specific vacancies exist for aeronautical, civil, electrical, electronics, industrial, marine, and mechanical engineers, and for mathematicians, Naval architects, physicists, and others, with salaries ranging from $2,974.80 to $10,330. Some of the positions involve occasional travel to Naval Shore Establishments for the purpose of observing or participating in scientific tests of Naval equipment. Others require original research or planning scientific programs. All of the positions are concerned with the most recent advancements in the scientific field. Applications for the positions should be made on Standard Form 57, available at any first- or second-class Post Office, and should be mailed to Code 612, Room 1213, Main Navy Bldg., 17th and Constitution Ave., Washington, D.C.

Electrical and Aeronautical Engineers—Corporation engaged in development of aircraft remote control and telemetering equipment has need for engineers of several categories: (1) Young graduate electrical engineers having good background in electronics and communications. (2) Graduate electrical engineers with experience in electronics and communications. (3) Graduate electrical or mechanical engineers having background in servomechanism design. (4) Aeronautical engineers having experience in stability and control. Wing Engineering Corporation, Colonial Bldg., Philadelphia 7, Pa.

Research Personnel—Employment opportunities are for engineering graduates interested in subsonic or supersonic aerodynamic testing and research. Employees desiring to undertake graduate study can arrange their working hours accordingly. Write to Department of Aeronautical Engineering, University of Washington, Seattle 5, Wash.

Instructors—One opening for an aeronautical engineering graduate with industrial experience appropriate for teaching stress analysis and aircraft structures. Other openings are available for engineering graduates who will teach engineering drawing and engineering mechanics. Part-time employment permitting intensive graduate study can be substituted if applicant wishes to obtain an advanced degree. Write to Department of Aeronautical Engineering, University of Washington, Seattle 5, Wash.

Aeronautical Engineers—Fairchild Aircraft Division, Hagerstown, Md., has vacancies in its Engineering Department at Hagerstown and also Branch Engineering Office, Washington, D.C., for engineering draftsmen, layout engineers, aerodynamicists, electrical engineers, structures and research engineers (with Ph.D. in Math. or Physics). For immediate details write Employment Manager, Fairchild Aircraft Division, Hagerstown, Md.

Jet Propulsion Engineer—Civil Service position open in Pasadena, Calif., in jet propulsion research and development field. An aeronautical engineer with strong thermodynamic and chemistry background preferred, although chemist or chemical engineer with some aeronautical engineering experience or experience with explosives could qualify. Engineering degree and 4 years' experience or equivalent necessary. Salary $5,905.20 per annum. On applying please give brief sketch of personal qualifications, education, and experience. Address: Bureau of Aeronautics Representative, 15 S. Raymond Ave., Pasadena 1, Calif.

Physicist P-5—To head applied research and experimental group in rocket ballistics. Thorough training in theoretical physics and good understanding of experimental methods essential. Must be able to guide and vigorously prosecute programs involving both theoretical and experimental studies and keep them properly related. Salary $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Physicist P-5—To head ballistics measurement and development unit. Requires experience in developing instruments for measuring physical quantities. Must be able to analyze and foresee needs for new methods of measuring ballistics quantities. Experience in radar, magnetic, photographic, and optical development desirable, though no one type is essential. Salary $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Physicist or Aeronautical Engineer P-5—To head group responsible for the operation of experimental facilities for the free-flight and wind-tunnel testing of rocket and guided missile models. Thorough knowledge of supersonic wind-tunnel techniques essential, and some acquaintance with techniques for obtaining force measurements in free flight desirable. Salary $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Physicist or Aeronautical Engineer P-5—To head applied research group in aerodynamics and stability of guided missiles. Must have a good theoretical background in supersonic aerodynamics and be capable of directing performance and stability analyses and the design of the aerodynamic envelopes of guided missiles. Salary $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Physicist or Aeronautical Engineer P-5—To head applied research group in aerodynamics and stability of rockets. Must have a good theoretical background in supersonic aerodynamics. Some knowledge and experience in rockets and ballistics desirable but not essential. Salary, $5,904 per annum. Apply to J. T. Dale, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Aerodynamicists and Aeronautical Engineers—Positions available for highly qualified technical personnel with good theoretical or experimental background to engage in development of facilities and model test work in stability, control, high-speed, and supersonic aerodynamics. Projects include new models of piloted and pilotless aircraft, new wind tunnels and associated equipment, and advanced testing techniques. Salary in accordance with qualifications and Civil Service regulations. In reply, please give summary of personal qualifications, education, and experience. Address—Director, David Taylor Model Basin, Washington 7, D.C.

907. Engineering Administrator—For instrument development laboratory in New York Metropolitan area. Experience on design, development, and manufacture of aircraft instruments, telemetering equipment, and servomechanisms desirable. Own engineering talent less important than ability to organize and direct others. Salary: $6,000 to $10,000.

895. Research Scientists—Experienced research scientists with advanced degrees and experience in applied physics, aerodynamics, thermodynamics, mathematics, or chemistry to perform supervisory research and act as permanent consulting group to engineering laboratory. Excellent opportunity for men with right qualifications. Salary, $8,000–$14,000 bracket.

894. Aeronautical Engineer—With Master's Degree to head aeronautical option in mid-western college. Should preferably have teaching and industrial experience. Salary open.

893. Engineers—West Coast airplane manufacturer has need for additional aerodynamicists, stress analysts, and airplane control system designers having experience with servomechanisms and automatic pilots.

885. Engineer-Salesman—To head up engineering or sales, or both, of long-established company manufacturing aircraft fuel, oil, air, and water injection pumps, valves, etc. Proper man can qualify as Chief Engineer or Sales Manager. Must be experienced in design and manufacture of these products, be conversant with Air Force and Navy Requirements, be alert to sales opportunities, and have good knowledge or experience in sale of these products. Excellent prospects for profitable future. On initial application please give complete information, including former employers, duration of employment, responsibilities, name of immediate supervisor, salary, etc. Location—Middle West.

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906. Management or Engineering—B.S. in A.E. Ten years' experience including teaching, aircraft stress analysis, and aircraft propellers. Six of these years as Assistant Chief Engineer and Chief Engineer in propellers. Will accept position in other fields as well as aircraft.

905. Aeronautical Engineer—M.S. in Aeronautics from M.I.T. Just completed 16 years'

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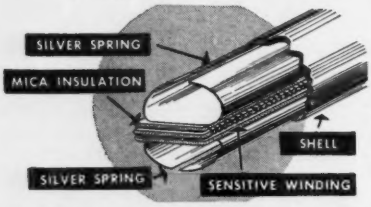

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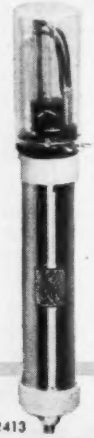

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903. Public Relations Representative—Seven years' experience in the active promotion of aircraft and propellers by teaching; lecturing societies, industrial, and civic groups; preparing publicity programs and press releases and over 40 technical and trade articles and papers. Writer—Editor of 1947 First Award Winning Paper of Lincoln Arc Welding Foundation contest. Foreign experience (Europe) representing U.S. aircraft manufacturer. Member U.S. T.I.I.C. team which explored German industry and returned latest developments to this country. Experienced in conducting plant tours, trade displays, civic, educational, press relations, and advertising agency liaison. Has had charge of entire program to introduce a unique mechanical product, educate the sales organization, and inform the trade and public. Desires position with manufacturer making finished mechanical products who requires the aggressive practice of public relations in the modern concept. Gas-turbine field of especial interest. Two years of college, 1 year of technical school. Age 29; married.

902. Engineer—B.Sc. Ae.E., M.S. in Ae.E., specializing in propulsion, aerodynamics, and research techniques for supersonic flight. Recipient of three scholarship awards for outstanding work as an undergraduate. Reads and speaks French and German. Has done tutoring in physics and aeronautics. Three years' experience in research, development, and manufacture planning for aircraft instruments and a subsonic wind tunnel. Two years' experience with the A.A.F. as an aeronautical engineer on the headquarters staff of an overseas air force. Duties of this position included personal responsibility for maintenance supervision of all troop-carrier aircraft, as well as P-38 fighters, and research into combat modifications to both types of aircraft. Desires engineering position in propulsion or aerodynamic research or as a teacher of these subjects.

901. Aeronautical or Mechanical Engineer.—B.S. degree in Aeronautical Engineering. Graduate student for 1½ years in Aeronautics and Applied Mechanics. Two years' experience in the aircraft industry as a senior draftsman and aerodynamicist. Desires a position in stress analysis or aerodynamics and other related engineering work. Will accept position anywhere in the U.S. or abroad.

900. Aeronautical Engineer—Age 36; married. Two and one-half years with major aircraft manufacturers as a specialist in weights and balance, technical writing, technical reports, and specifications writing. Able to handle and familiar with machine-shop practice. Holds a valid A. & E. license from the C.A.A. Has had approximately 12 years' all-around experience on transport and private-type aircraft as a technician. Would like position as technical reports writer, liaison, and/or maintenance engineer.

899. Engineer—Housing requires a change of position this fall. Associate Professor, Aeronautical Engineering; age 32; large mid-western university. Technical Director of sponsored powerplant research project. Industry or university position considered. Rental housing for family of five a necessity.

898. Engineer—B. Aero. E., M. Aero. E. Three and one-half years' industrial experience, including over 2 years' aerodynamics in wind tunnel, performance, air loads, stability, and control. Past 1½ years as experimental research engineer with East Coast precision instrument corporation. Duties included design and operation of experi-

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mental equipment. Graduate studies include aerodynamics, both theoretical and applied, aviation gas turbines, stress analysis, dynamics of aircraft. Would prefer teaching position in New York area but will travel if necessary.

897. Associate Professor—Ph.D. in Applied Mechanics, degree in Aeronautical and Mechanical Engineering. Five years' experience in industry and research; head of structures department with aircraft manufacturer. Wishes to obtain university position teaching theoretical graduate courses in applied mechanics or mathematics, with opportunities for research.

896. Industrial Engineer—Three years' aircraft development and manufacturing experience. B.S. in Ae.E., M.S. in Industrial Engineering (June 1948). Immediately available.

892. Engineer—B.A.E., 1946. Age 22; married. Two years' experience as project engineer engaged in research, development, and testing at a large wind-tunnel establishment. Experienced in organizing and directing projects; analyzing wind-tunnel data and writing technical reports; dealing with people such as representatives of government bureaus and contracting companies. Interested in permanent position in business associated with aircraft sales. Open to any interesting offer affording possibilities for good future. Eastern U.S. location preferred.

891. Professor—Professor of Aeronautical Engineering desires change to position in more favorable climate. Industrial experience as chief aerodynamicist. Papers on dynamics and thermodynamics. Advanced degree.

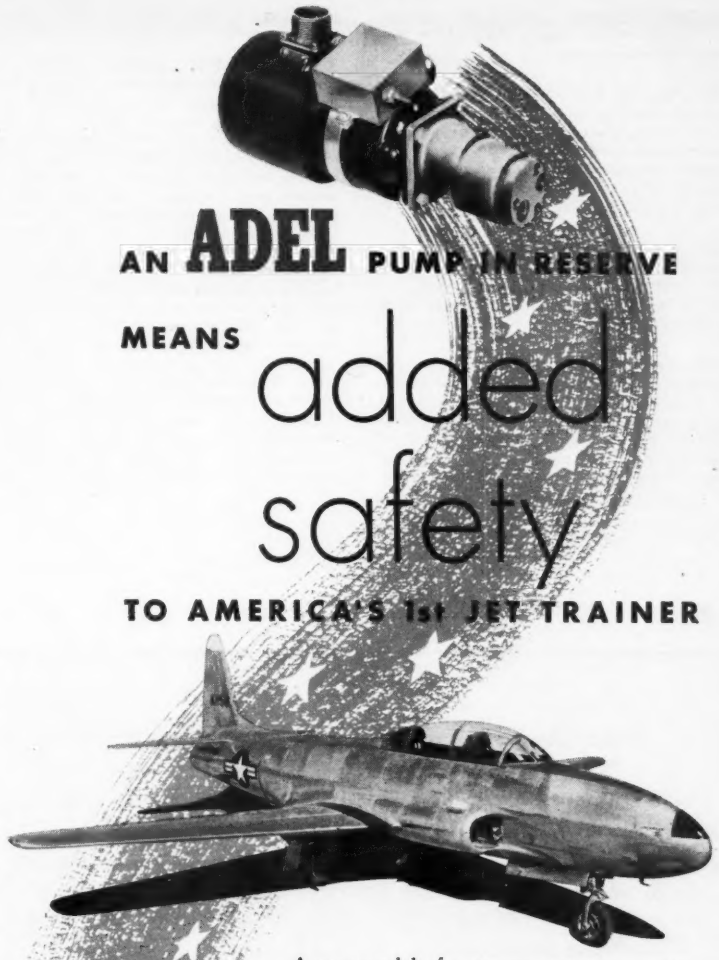
890. Aeronautical Engineer—B.A.E. New York University, 1940. Broad experience in general design and research as group leader. Three years as project engineer in jet propulsion research and experimental helicopter design. Available New York area on part-time or consulting basis only.

886. Engineering Pilot—B.S. Aero. E., University of Michigan. Age 30; married. Twelve years' flying experience. Pilot—commercial airplane single- and multiengined land with instrument and flight instructor ratings; 2,300 hours' total flying time, 1,500 multiengined. Three and one-half years' flight-test experience with West Coast manufacturer as engineering test pilot. Two and one-half years' experience with air line as air-line pilot and engineering pilot. Familiar with flight analysis and C.A.A. requirements. Desires position as engineering pilot with manufacturer or air line.

884. Flight-Test Aerodynamics Engineer—B.S. in Ae.E., University of Michigan, 1942. Age 27; married. Flight-test analysis or planning position desired by aerodynamics engineer with 3 years' high-speed military aircraft aerodynamics experience, including static stability performance, wing and flap design, and some wind-tunnel testing and flight-test work. Three years' pilotless aircraft aerodynamics experience, primarily in the supervision of flight-test planning, preflight calculations, and flight-test analysis and, secondly, including work on performance, wind-tunnel test analysis, stability, air loads, and special problems. Concurrently with above, 1 year's experience teaching aerodynamics in night college and 1 year's experience designing light aircraft.

883. Aeronautical Engineer—B.A.E. Cum Laude. Five years' experience in aeronautical research, including compressible flows, propeller research, wind-tunnel fan and ducted fan design. Desires position in research near or with university providing opportunity for work toward advanced degrees.

882. Engineer—Ten years' responsible experience in production and development of electromechanical equipment. Excellent relationship with factory personnel and customers. Espe-



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880. Engineer—Brazilian; Rensselaer Polytechnic Institute graduate; speaks English fluently; resides in Rio de Janeiro. Desires to work with, or for, an American company in a technical or administrative capacity.

879. Research Aerodynamicist—Six years' experience includes teaching, Wright Field experience in performance and missile study, consulting on missile projects. At present employed in transonic research. Desires location in West Coast region with opportunity to do work on advanced degrees during next 4 years. Will consider salary in keeping with cost of living, and can be available in either Summer or Fall of 1948 by exercising option clause in present contract.

878. Aeronautics Teacher—Aviation educational consultant, high school and college levels. Author of two books on aviation education; at present teaching industrial arts aeronautics in southern high school. Desires change to college level. Specializes in lectures and demonstrations together with practical work on such subjects as aerodynamics, structures, aircraft engines, instruments, propellers, navigation, meteorology, Link Trainer, aircraft radio, general operational aircraft methods. Designated C.A.A. aircraft and aircraft-engine examiner. Equipped with aviation teaching devices such as sound and slide films and necessary projection equipment, mock-ups, and demonstration devices of all phases, teaching devices, demonstration equipment.

877. Stress Analyst—B.Ae.E.; married. Employed by large aircraft manufacturer on West Coast for past 4 years, but now seeks location within 150 miles of New York City. In present classification for year and a half. Previous experience in structural design group and structural test.

876. Aeronautical Engineer—B.Ae., University of Detroit. Canadian citizen; age 28; married. Seven years' general experience in such phases as: design of aircraft components, shop, and ground equipment; structural analysis; plant layout; technical analysis and administration. Last 5 years as service engineer with large Canadian air line on maintenance and operational problems. Familiar with C.A.A. and British requirements. Seeks wider experience in the aeronautical or related fields. Will locate anywhere in Canada, United States, or abroad.

868. Management or Administration—A.B. degree, University of Pennsylvania; 28 years old, single. Major in political administration, courses applicable to business administration. Courses in industrial engineering including industrial relations, business and Government, organization and organizational structure. Aeronautical engineering courses in elementary aerodynamics, performance calculation, aircraft drafting, and engineering. Over 4 years in aircraft testing in present position. Desires permanent position on junior level in management or administration with opportunity for advancement. Philadelphia, Pa.

Announcing a New Journal Department . . . Readers' Forum

It has been suggested by several members of the I.A.S. Editorial Committee that the *Journal* open a special department to fill the need for the more immediate communication of essential results of research in the greatly expanded and accelerated fields of the aeronautical sciences. Therefore, it has been decided to establish a new department, the "Readers' Forum," which will include letters to the editor for the quick publication of (1) brief reports of important findings in aeronautical sciences and (2) discussions of papers published in the *Journal*.

Specifications for Submission of Material

(1) All letters should be accompanied by a suggested short title, giving some indication to the reader of the subject under discussion.
(2) These letters should not exceed 800 words in length.
(3) Publication will be completed 6 to 8 weeks after receipt of the material.
(4) The Editorial Committee will not hold itself responsible for the opinions expressed by the correspondents, and no proofs will be sent to the authors.
(5) All letters should be double-spaced.

It is hoped that the new department may be started with the January, 1949, issue of the *Journal*. Contributions should be sent to:

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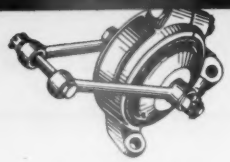
RS-40G ASSEMBLY

[Consists of six RS-40G-SA sub-assemblies]

For LOCKHEED "CONSTELLATION"
DOUGLAS AD-1 & AD-2
MARTIN "MARS" (JRM-1)
Using Wright R-3350-C18BB and C18BD engines



RL-35 ASSEMBLY

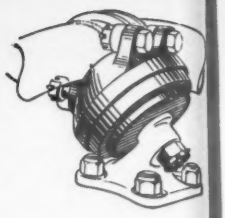
[Consists of nine RL-35-SA sub-assemblies]

For LOCKHEED "CONSTELLATION" Using Wright R-3350 A & B Series Engines

MR-36 and MR-36F ASSEMBLIES

[Consist of six MR-36-SA, six MR-36F-SA sub-assemblies respectively.]

For CONSOLIDATED "240"
CURTISS CW-20 (C-46)
DOUGLAS DC-6 (C-112)
FAIRCHILD "PACKET" (C-82)
MARTIN 202



Using Pratt & Whitney R-2800 A & B Series Engines, use MR-36; Pratt & Whitney R-2800C Series Engines, use MR-36F

DUPLICATE ORIGINAL PERFORMANCE REPLACE WITH LORD DYNAFOCALS

Follow the lead of companies like Lockheed, Martin and Douglas who use Lord Dynafocals as original equipment... you'll get better vibration isolation, longer service life and lighter weight.

Check these features:

- ***Smoother flight***—flexible center-of-gravity suspension means maximum vibration isolation.
- ***Low weight***—careful design and stress analysis assures minimum weight.
- ***Maximum safety***—all parts are 100% Magna-fluxed. Metal parts interlock for positive safety.
- ***Less engine movement***—rubber snubbers limit unusual engine movement, prevent metal-to-metal bottoming.
- ***Easy installation***—metal parts are interchangeable due to precision construction methods.

Write for a copy of Lord Service Bulletin containing valuable information on maintenance problems, suggestions for increased service life, and parts list. Mention engine or mounting in which you are interested.

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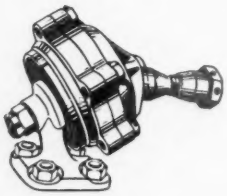
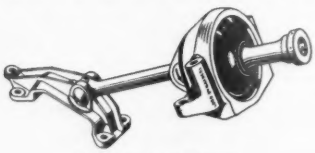


MR-26 ASSEMBLY

[Consists of eight MR-26-SA sub-assemblies]

For DOUGLAS DC-4 (C-54)
Using Pratt & Whitney R-2000 Series Engines



MR-40D ASSEMBLY

[Consists of seven MR-40D-SA sub-assemblies]

For BOEING 377
BOEING B-50
DOUGLAS C-124
MARTIN P4M1
MARTIN AM1
FAIRCHILD C19

LORD ENGINE MOUNTINGS for DC-3

Item	P&W 1830 Series Quantity Per Plane	P&W 1830 Series Part Number	Wright 1820 Series Quantity Per Plane	Wright 1820 Series Part Number
Tube Mounting	8	J 1202-1	8	H5013-3
Insert	16	J 1789-1	18	SK1925-1
Sandwich	32	SK1292-1	36	SK1292-2

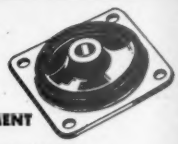
LORD Vibration Control Systems

INSTRUMENT PANELS

Get all-directional protection with one-piece Multiplane Mounts (see cut) on new jobs. For efficient replacement on earlier installations install Lord Plate Form Mounts.

COWL MOUNTS

Protect cowls against shock, vibration, and engine expansion with Lord Tube Form Mounts, illustrated. Use these, too, for flap-jack joints—wherever flexible joints are required.



RADIO, NAVIGATION COMMUNICATION EQUIPMENT

Specify Lord Multiplane Mounts for isolation of vibration from all directions. Lord Plate Form Mounts (shown above) also available for replacement.

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